*N-*ー

5220/

P- '14

The Effects of Crew Resource Management (CRM) Training in Airline Maintenance: Results Following Three Years Experience

J. C. Taylor and M. M. Robertson

National Aeronautics and
Space Administration

N95-28676

Unclas

G3/53   0052201

(NASA-CR-196696)   THE EFFECTS OF
CREW RESOURCE MANAGEMENT (CRM)
TRAINING IN AIRLINE MAINTENANCE:
RESULTS FOLLOWING THREE YEAR'S
EXPERIENCE (University of Southern
California)   74 p

The Effects of Crew Resource Management (CRM) Training in Airline Maintenance: Results Following Three Years Experience

J. C. Taylor and M. M. Robertson

Institute of Safety and Systems Management
University of Southern California
Los Angeles, CA 90089-0021

National Aeronautics and
Space Administration

Ames Research Center
Moffett Field, California 94035-1000

THE EFFECTS OF CREW RESOURCE MANAGEMENT (CRM) TRAINING

IN AIRLINE MAINTENANCE:

RESULTS FOLLOWING THREE YEAR'S EXPERIENCE

Report of Work Completed through 12-31-94

SUMMARY

This report describes three year's evaluation of the effects of one airline's Crew Resource Management (CRM) training operation for maintenance. This evaluation focuses on the post-training attitudes of maintenance managers' and technical support professionals, their reported behaviors, and the safety, efficiency and dependable maintenance performance of their units. The results reveal a strong positive effect of the training.

The overall program represents the use of CRM training as a long-term commitment to improving performance through effective communication at all levels in airline maintenance operations. The initial findings described in our previous progress reports are reinforced and elaborated here. The current results benefit from using the final pre-post training survey population , with a total of over 2,000 managers and staff professionals. Additionally there are now full results from the two-month, six-month, and 12-month follow-up questionnaires, together with as many as 33 months of post-training performance data, using several indicators.

In this present report, we examine participants' attitudes, their reported behaviors following the training, the performance of their work units, and the relationships among these variables. Attitudes include those measured immediately before and after the training as well as attitudes of the participants months after their training. Performance includes measures, by work units, of on-time flight departures, on-schedule maintenance releases, occupational and aircraft safety, and efficient labor costs. We report changes in these performance measures following training, as well their relationships with the training participants' attitudes.

1

Highlights of results from this training program include increased safety and improved costs associated with positive attitudes about the use of more assertive communication, and the improved management of stress. Improved on-time performance is also related to those improved attitudes, as well as favorable attitudes about participative management. More specific results are as follows:

1) We note positive trends in a number of the company's overall maintenance performance indicators for the months after the onset of training (variously 27 to 34 months, depending on the measure), compared with the months before (varying from 5 to 17 by measure). Measures in the Safety Performance category improve in the 32 months measured after the training. In addition, results in the Dependability Performance category continue to improve in the 27 months measured after the onset of training. The available measure for Efficiency also shows generally effective performance during the first 18 months following training, but then performance slips for the remaining 16 months measured.

2) Comparisons of managers' attitudes immediately after their training, with their pre-training attitudes, show significant improvement for most of those expected. Improvement is noted in attitudes about "willingness to share command responsibility," "usefulness of communication & coordination," and "recognition that stressors effect management decision making." The same attitudes of these managers two-, six-, and 12-months later, reveal that these favorable post-training attitudes remain at those high levels in the months after the training. The fourth attitude scale measured, "willingness to voice disagreement" (a measure of assertiveness), although showing no significant change immediately following training, improved significantly above the pre-training levels two months after training and it remained at that higher level six and 12 months afterwards. The influence of the training on all the expected participant attitudes is thus a stable and robust change, and not merely a brief "honeymoon effect."

3) Other analyses of the data look at the relationships between pre-, and post-training attitudes and maintenance performance over several years. In this "time-lagged" correlation analysis we tested the effects for performance before the onset of the training program, immediately after the training program and for subsequent effects on performance months after the training and/or follow-up surveys began.

We found a pattern of significant relationships between the participants' pre-training and post-training attitudes and performance. Attitudes about skills and behaviors specifically taught in the CRM training were predictive of subsequent maintenance performance. Attitudes, immediately following training, about the value of communication & coordination, as well as about the "value of stress management," were found to be related to on-time scheduled maintenance performance both prior to and after the training began.

The strongest effects of CRM training appear on respondent attitudes two months after their training. Examination of that two-month follow up survey reveals that attitudes about sharing command responsibility, and about assertiveness (both of these are "active" beliefs emphasized in the training, and which require behavioral support to reinforce them), are related to subsequent on-time flight departures, and occupational safety. Attitude about sharing responsibility is also related to many months of timely maintenance work both before and after the training began. Overall, the correlations between performance and the attitudes measured in this two-month follow-up survey are remarkably strong and indicate that lessons learned from the CRM training have consolidated after two months, and in "active" ways.

The six-month follow-up results show a retreat from the effects in the 2-month survey. The 6-month results reveal that only prior maintenance performance is related to surveyed opinions about delegation, communication and stress management.

By the 12-month follow-up survey, the CRM training effects have returned to mirror aspects of the post and 2-month surveys. Results of this later survey suggest that the lapse at 6 months probably represents a consolidation of the training effects rather than their elimination. Training participants continued to develop the skills they learned in CRM and used them to good effect. Attitudes about the value of assertiveness one year after CRM training were related to many months of occupational safety both before and after that survey was taken. Attitudes, a year after training, toward sharing command decisions were (reminiscent of the 2 month results) also related to many months of occupational safety. Finally, 12-month attitudes about managing stress effects were associated with improved performance in the very stressful performance areas of meeting ambitious goals for cost saving, and for timely maintenance. These findings strongly suggest that lessons of stress management, learned during training more than a year earlier, had also developed and matured for the training participants.

THE EFFECTS OF CREW RESOURCE MANAGEMENT (CRM) TRAINING

IN AIRLINE MAINTENANCE:

RESULTS FOLLOWING THREE YEAR'S EXPERIENCE

J.C. Taylor Ph.D. & M.M. Robertson Ph.D.

Institute of Safety and Systems Management

The University of Southern California

Los Angeles, December 1994

THE STUDY

Background

The CRM program reported here involves initial training in several team-related concepts, including communication skills, self-knowledge, situational awareness, and assertiveness skills for maintenance management and support staff personnel in one large U.S. airline (hereinafter called "the company"). Maintenance (or "Technical Operations") in this company includes engineering, quality assurance, technical planning, systems & procedures, contracts administration and purchasing, as well as the more direct maintenance functions of line- and base-maintenance, inspection, shops and material services. The company succeeded in training all of its maintenance directors, managers, supervisors and assistant supervisors, engineers, planners, coordinators, and schedulers, as well as a large part of its inspection staff. According to company records, 2,199 people in total completed the CRM for Maintenance course between June 1991 and March 1994.

CRM training in airline maintenance operations was highly unusual when introduced into the present organization. This exceptional example has been intensively studied over a three year period. The first papers (cf., Taylor, 1991a, 1991b) reported the methodological and measurement characteristics of the attitude and performance indicators used. Subsequent reports have been limited to a relatively small sample of participants, and a small number of months of maintenance performance data subsequent to the training. A summary report of the first six months experience (prepared by Taylor, Bettencourt & Robertson, at the University of Southern California in 1992) was published in the FAA Office of Aviation Medicine's second annual human factors R&D progress

report (Galaxy, 1993); and a subsequent report on the first full year's experience (also prepared at the University of Southern California in 1993) has been included in the FAA Office of Aviation Medicine's third progress report (Galaxy, 1994). Several shorter papers dealing with selected topics from this study have also been published (Stelly & Taylor, 1992; Taylor, Robertson, Peck, & Stelly, 1993; Robertson, Taylor, Stelly, & Wagner, In Press). The present report concludes the evaluation of the company's initial program, by documenting the mutual effects between training-related attitudes and behaviors and work unit performance, as well as the persistence and stability of the attitude and behavioral changes following the training.

The effectiveness of this training, as measured by its ongoing evaluation, can help direct both the NASA and airline industry's maintenance human resources practices in the future and guide the development of future ATA and FAA training policies and regulations.

The analyses reported below assess the relationships among respondents' training-induced attitudes about a variety of management and organizational items, their reported post-training behaviors, and maintenance unit performance.

The Purpose of the Program and of the Course.

The program's champion was the company's Senior Vice President for Technical Operations. He announced that his aim for the joint training and evaluation program was to improve human resource (HR) management by using science-based tools and techniques for evaluating the training outcomes and using those results for continuously improving the program's effectiveness (Fotos, 1991).

This particular training program originally began with advice and assistance from the company's flight operations training group who had nearly a decade's experience with their own CRM program. After that initial assistance, the company's flight operations and technical operations (i.e., maintenance) CRM programs were directed and administered separately. During the first three years of that maintenance CRM program it continued to be managed and administered by maintenance personnel, and the trainers were mainly maintenance people too.

The purpose of the training, as reiterated by trainers on the first day of each training session, was "To equip all maintenance personnel (management first) with the skill to use all resources to improve safety and efficiency."

Course objectives. The objectives (the more specific goals of the training) were also clearly stated during the trainers' introductory remarks:

1) Diagnose organizational "norms" and their effect on safety.

2) Promote assertive behavior.

3) Understand individual leadership styles.

4) Understand and manage stress.

5) Enhance rational problem solving and decision making skills.

6) Enhance interpersonal skills

The course was designed for the objectives. The aims and objectives of the training were achieved by following a course syllabus containing 12 modules (Appendix A contains the syllabus).

The first phase of training completed. By the conclusion of this phase of the CRM training intervention, in February, 1994, nearly 2,200 participants had attended the course. Called "the first phase" of training, it included all Technical Operations management and staff professionals, and it is the subject of this present report. During early 1994, the usual number of new hires or recent promotions to management ranks continued to attend the CRM course and those sessions were also attended, for a few months, by Aircraft Inspectors, as the beginning of a second phase which would include all mechanics and inspectors in the training. The present analysis uses data from the entire sample of maintenance management, salaried professional staff, and inspectors (n=2,199) who participated in the "first phase" training course between June 1991 and March 1994.

Individual respondents as the focus of analyses. To explore some of the effects of the training on all individuals, the data from all training participants will be used. The remaining (and majority of those) analyses, however, examine the attitudes of respondents who (through the use of their confidential code numbers) can be matched between the pre-training survey and the later ones.

Maintenance work units as the focus of analyses. The maintenance performance data (classified into categories of "safety," "dependability," and "efficiency") were measured by work units, not by individual respondents. The analyses described in this report illustrate the effect of changes in respondent attitudes upon the maintenance performance of their work-units. For managers these are the units they lead, and for staff professionals, maintenance foremen, and inspectors these units are the stations and locations to which they belong. In order to accomplish the examination of attitudes correlated with performance, the individual respondent's attitude data were combined into averages for the appropriate units.

The "Crew Resources Mgt/Tech Operations Questionnaire" (CRM/TOQ)

Prior experience in measurement of attitudes related to CRM training. The Cockpit Management Attitudes Questionnaire (CMAQ) has long been a recognized measure for assessing flight crew attitudes. It is useful as a training, evaluation and research tool (cf., Helmreich, Foushee, Benson, & Russini, 1986). The 1990 CMAQ

questionnaire contained 25 items measuring attitudes that are either conceptually or empirically related to CRM. Taggart (1990) revised the CMAQ for use in a maintenance department, and reported positive initial results following CRM training conducted for maintenance managers in late 1989.

Two previous studies have explored the CMAQ instrument for a consistent internal structure using the Factor Analysis technique (Gregorich, Helmreich, & Wilhelm, 1990; Sherman, 1992). In these two studies, using samples of flight crews and air traffic controllers, the authors showed that the relationships among the 25 CMAQ items clustered into the following four constellations of attitudes:

1) Sharing Command Responsibility,

2) Value of Communication & Coordination,

3) Recognizing and Managing Stressor Effects,

4) Avoidance of Interpersonal Conflict

Gregorich, et al. (1990) eventually reduced their set from four to three composites by dropping "Avoidance of Interpersonal Conflict." Sherman, on the other hand, found that fourth factor to be much more robust in his sample of Air Traffic Controllers, and he titled it "Advocacy and Assertiveness." Those authors combined the individual CMAQ items into three or four composite index scales, respectively, to obtain more stable indicators of underlying concepts. Such indices permit a more detailed assessment of the separate but related attitudes than a single total score for the entire questionnaire, but they also provide more accurate and reliable results than are available from each of the individual questionnaire items alone.

Measurement of attitudes in the present study. The "Crew Resources Management/Technical Operations Questionnaire" (CRM/TOQ) developed for the present study is a modified version of Taggart's revised CMAQ. In choosing to draw on the CMAQ to obtain a "good" measure of the complex concepts of CRM training, the - company and the researchers wished to start with a survey, already proven valid as an measure of CRM training in the airline industry. The two parties also wanted more maintenance related measures than the CMAQ provided -- in particular they wished to measure opinions, important in maintenance, but which were not expected to change following the training; as well as rather more specific expectations for future use, as well as reports of how the training was subsequently used. The CRM/TOQ followed the successful format set by the CMAQ, in that it is a short questionnaire, yet having enough items to provide convergence to a smaller, easily used, set of concepts.

The CRM/TOQ contains 26 multiple response items. The company's modifications of the CMAQ involved removing five questions and adding six others. The five questions were removed because they either lacked predictive validity as reported by earlier flight

crew studies (Helmreich, et al., 1986) or, in the company's opinion, lacked relevance to maintenance.

A confirmatory Factor Analysis was undertaken for the data obtained with the CRM/TOQ (Taylor, 1991a). Results for the items drawn from the revised CMAQ were similar to those of Gregorich, et al. (1990), and subsequently with Sherman (1992). As in Sherman's study, the CRM/TOQ's fourth composite was statistically strong, and was therefore retained as the reflected index "Willingness to Voice Disagreement."

Six questions were also added to the CRM/TOQ, based on items intended to measure respondents' perceptions of behaviors dealing with setting and attainment of work goals (Geirland & Cotter, 1990). These six individual items were considered important to add because the work of maintenance managers differs from that of Flight Operations' officers (as managers) in the typically longer time required for Technical Operation's goal attainment and the relatively greater ambiguity of those goals. In addition, because goal setting and attainment were not covered in the CRM training such items could act as "control questions" about events in the respondents' work lives which were not predicted to change in a consistent or positive way following the training. These questionnaire items were separately tested by Factor Analysis and results suggested a two factor structure: "Goal sharing in one's own group," and "Goal sharing with other groups."

Table 1 displays the six scales calculated from the CRM/TOQ and which are used to test the effects of the CRM training on individual participants. Table 1 presents those six scales and the numbers of the individual item used to calculate each one. The individual item numbers correspond to the numbering of the sample questionnaire located in Appendix B.

TABLE 1

Scales Used to Test Individual Effects of CRM Training

SCALE	CONSTITUENT ITEMS (See Appendix B)
Scales Sensitive to CRM	
Sharing Command Responsibility	6, 8, 11, 13, 19 (reflected)
Communication & Coordination	5, 12, 14, 16, 17
Managing Stress	9, 20
Assertiveness	1, 2 (reflected)
"Control Scales"	
Sharing Goals in own Group	21, 22, 23, 24
Sharing Goals with other Groups	25, 26

Measurement Characteristics of the CRM/TOQ. Both reliability and validity of the separate items and the composite scales were tested, and they demonstrated good measurement qualities (Taylor, 1991a).

Four versions of the CRM/TOQ. There are four versions of the CRM/TOQ questionnaire which were used in various phases of this project.

1. A "Baseline Questionnaire" was mailed to all 1,800 maintenance managers, supervisors, and assistant supervisors in the company in May 1991, before the training was announced. The results of this baseline assessment of management attitudes were used in the Factor Analysis described above and were also used to establish the reliability and validity of the CRM/TOQ (Taylor, 1991a). The Baseline data were also compared with the subsequent "Pre-training" survey and the comparable questions' mean scores were found to be virtually indistinguishable from one another (Taylor, Bettencourt & Robertson [Galaxy], 1993). The baseline survey played no further role in the present study. The first 26 multiple-choice questions were used (with only minor variations) for all subsequent versions of the CRM/TOQ.

2. A "pre-training" questionnaire was completed by all participants immediately before each workshop began. Respondents were asked to choose a private identification (I.D.) or code number and to write it on their questionnaire. It was explained that this number would allow their responses to be compared with their responses on subsequent, follow up questionnaires, but without identifying them. These pre-training attitudes were subsequently compared with attitudes immediately after the training, as well as with attitudes measured months later.

3. A "post-training" questionnaire was completed by participants at each workshop's conclusion. Respondents, again, wrote their I.D. code on the questionnaire; and were asked to note that number in their course workbook to help them remember it for later "follow-up" questionnaires. The training facilitators collected and mailed the completed pre-training and post-training questionnaires to the University for processing. Data from this post-training version of the CRM/TOQ were compared with the pre-training questionnaire data. As described further below, three attitude scales had statistically higher mean scores immediately following training. The fourth attitude, "assertiveness," was not statistically higher immediately after training. The two opinion scales about goal sharing were not statistically different before and after the training.

4. "Follow-up" questionnaires were individually mailed by the company to all past participants two, six, and twelve months following their CRM training. Respondents were again asked to include their private I.D. code on their questionnaires, so that those follow-up surveys could be matched with the earlier questionnaires. They were provided an pre-addressed and stamped envelope with which to return the questionnaires to the University for processing. Although the 2, 6, and 12 month follow-up surveys were all identical in form, they measured the

respondents' thoughts, assessments, and attitudes over increasingly lengthy periods from the training (an example of the CRM/TOQ Follow-up questionnaire is included in Appendix B).

Questionnaire return rates. Table 2 presents the return rates for the five surveys reported here. The total number of surveys returned and the percentage returned are shown for each survey.

TABLE 2

Sample Size And Response Ratios: Five Surveys

CRM/TOQ Questionnaires Received by October, 1994 (2,199) total participants)

SURVEY	TOTAL RETURN	RETURN RATE
Pre-training Survey	2,056	93%
Post-training Survey	2,053	93%
2-month Follow-up Survey	810	37%
6-month Follow-up Survey	722	33%
12-month Follow-up Survey	540	25%

The high return rate for the pre and post-training surveys result from participants being asked to complete the questionnaires while they were present in the training sessions. Lower return rates for the subsequent follow-up surveys is the normal result of surveys conducted by mail, but the 25%-37% return rates displayed in Table 2 are lower than desired. During the first year of the CRM program, we reported that the follow-up survey return rates ranged from 40%-45% (Taylor, Bettencourt & Robertson [Galaxy], 1993). During the intervening two years, although maintenance management continued to fully support their CRM program, the company experienced considerable turbulence in its markets and it reacted with several waves of staff reductions and station changes (including closures in several cases). These changes introduced consequent personnel moves which made it extremely difficult for the CRM course administrators to subsequently locate course participants to send them surveys. The lower follow-up survey return rates for the entire three years reflect this administrative difficulty -- using out of date or incorrect address lists caused many questionnaires not to be sent to their intended recipients. Although lower morale due to layoffs and station closures can be hypothesized

to contribute to a lower return rate, the stable attitudes measured in the considerable number of follow-up questionnaires received do not reflect it.

Testing the effects of missing data on scale scores. In any survey instrument like the CRM/TOQ, individual respondents will occasionally make a mistake or omit an answer to a specific question. Such errors and omissions result in "missing data" (unusable answer, or no answer given). When individual items with missing data must be used with others with valid responses to form scales, such as we have done for the present study, the research investigator faces the choice of dealing with missing data for individual questions in three ways. The investigator: 1) can eliminate the scale in question for that respondent entirely, or 2) can calculate the scale score without the individual item included, or 3) can substitute the population mean score for that item to replace that respondent's "missing data." Each approach has advantages. The first and second alternatives use only actual data, but the former reduces the sample size, and the latter biases the scale in favor of the remaining items. The third alternative maintains the sample size with a minimum distortion of the resulting score for the total sample.

We compared both the first and the third alternatives and examined the increase in sample size by replacing missing responses in individual items with the sample mean before calculating the scale score. There are four attitude scales, and two "control scales" (cf., Table 1), measured for both the pre and post-training administrations of the CRM/TOQ questionnaire, for a total of 12 modified scale mean scores. The increase in total sample "n" using the third alternative modification was between 50 and 255, depending on the particular scale in question. As noted above, the total number of questionnaires returned was, 2,056 for pre-training, and 2,053 for post-training samples (cf., Table 2). The smallest "n's" using the unmodified scales were 1,801 and 1,804 for the pre-training "goal sharing" scales. After replacing the missing data for every individual item used to construct a scale the obtained "n" for every scale in the pretest and posttest was returned to 2,056 and 2,053 respectively.

We also compared the the third alternative modifications with unmodified scales to test the degree of possible distortion in scores introduced by the former. Mean values for the 12 scales, modified to correct for missing data, were compared with the 12 unmodified ones. Eleven of the 12 scales so modified were unchanged from the original (unmodified) data set. Only one of the "control scales," *"My unit shares goals with other work units in Technical Operations, "* was considerably higher in its modified form for the pre-test sample (0.30 scale point higher on a five-point scale). The modified post-test score for this scale was undifferentiated from the unmodified version. For 11 of the 12 items tested, using the population mean score to replace missing data was a net benefit -- it increased the sample size without affecting the scores themselves[2].

---

[2]The question of the outlier, however, still remains. Why should this one scale behave so differently from the rest? At least a part of the answer is that a number of senior administrative and management people reported very positive contact with other groups and, coincidentally, they also did not answer all the questions on that topic. The original data collected during the first few months of the program (June-Aug., 1991) showed a tendency to over-evaluate the items comprising this scale (cf., Taylor 1991a). A

Because replacing missing data with population means had no effect on 11 of the 12 scales so treated we used that modification for in all data analyses in the present report.

Testing CRM/TOQ questionnaire sensitivity. The quantitative questions in the CRM/TOQ were designed to obtain four independent attitude scales (cf., Table 1) and several individual opinion items, all specifically sensitive to the CRM training curriculum. There were also two "control" scales, dealing with perception of goal setting and attainment, which were specifically intended not to be sensitive to the training. As noted in the preceding section, one of these control scales was the only one of the six which was affected by the scale modification procedure to correct for missing data. Table 3 presents additional evidence for the differences between the CRM attitude scales and the control scales. Table 3 is a intercorrelation matrix between the four attitude and the two control scales from the pre-training survey and those six scales from the post-training survey. The cell entries are Pearson Product Moment Correlation coefficients ("r") and those in *italics* are statistically significant at the .05 confidence level or higher. **Boldface** coefficients are those above r=.49, representing unusually high correlations, -- those which account for at least 25% of the joint variance of the two correlated scales. That would mean that about 25% of a given attitude scale's fluctuation was explained by the fluctuation of the other scale in correlation with it.

---

disproportionate number of respondents during those first few months of training were senior executives and managers. These respondents, as a group, probably feel more certain in their views, and thus would be expected to have a lower missing data rate, and would also be more likely to have an answer to questions about "other groups" in Technical Operations. After that initial few months, the pre-training mean scores for that scale, settled to a lower level which remained unchanged from the post-training scores for the remainder of the nearly three years we measured. The individual questions dealing with goal sharing with other groups had a higher missing data rate (were answered less often) than all other multiple response questions. In the later training sessions an increasing number of respondents did not answer one or both of the questions asked about the topic. Later respondents probably felt less certain about this concept and those source behaviors. In the final sample there are 252 (roughly 12% of the population) pre-training subjects who did not answer one or both of the questions comprising the scale, "My unit shares goals with other work units in Technical Operations." When we examined the differences across the various departments in Tech Operations, we found that pre-training modified scale scores for the mechanical trades departments (line, base, and shop maintenance) were largely unchanged from their original data. However, personnel in the other Technical Operations departments (many of them higher managers) showed marked increases in their scores when their pre-training data set was modified, which means that the one item in the scale that they did answer, they answered very positively. Adding the sample averages to these very high scores appreciably raised the total scores for this scale. The fact that his group would both answer positively and skip questions on this topic is either a coincidence or an unknown measurement artifact affecting that one scale.

TABLE 3
Intercorrelations among Pre-training and Post-training Survey Scales

	Pre-Training: Delegating Command Responsibility	Pre-Training: Communication & Cooperation	Pre-Training: Managing Stress Effects	Pre-Training: Assertiveness	Pre-Training Control: Goal Sharing within Group	Pre-Training Control: Goal Sharing with Others	Post-Training: Delegating Command Responsibility	Post-Training: Communication & Cooperation	Post-Training: Managing Stress Effects	Post-Training: Assertiveness	Post-Training Control: Goal Sharing within Group	Post-Training Control: Goal Sharing with Others
Pre-Training: Del. Command Resp.	--											
Pre-Training: Communic & Coord.	.31	--										
Pre-Training: Mng. Stress Effects	.50	.39	--									
Pre-Training: Assertiveness	.28	-.01	.10	--								
Pre-Training Control Item: Goal Sharing w/Gp.	.01	.12	-.04	.01	--							
Pre-Training Control Item: Goal Shr w/Others	.05	.08	0.0	-.01	.74	--						
Post-Training: Del. Command Resp.	.52	0.0	.22	.26	0.0	.02	--					
Post-Training: Communic & Coord.	-.03	.38	.03	-.02	.13	.08	0.0	--				
Post-Training: Mng. Stress Effects	.23	.04	.48	.11	0.0	0.0	.35	.08	--			
Post-Training: Assertiveness	.18	-.02	.06	.47	.02	0.0	.28	-.04	.11	--		
Post-Training Control Item: Goal Sharing w/Gp.	-.14	.11	-.09	-.06	.44	.16	-.12	.21	-.10	-.03	--	
Post-Training Control Item: Goal Shr w/Others	-.15	.03	-.07	-.09	.24	.23	-.18	.11	-.12	-.09	.47	--
n = 1,822												

The pattern of intercorrelations in Table 3 shows that the best predictor of later attitudes are the same attitudes at the earlier time period. The pattern also shows the two control scales are more related to themselves and to one another than they are related to the CRM attitude scales. These results demonstrate that the four CRM attitudes are largely independent of one another (a desirable condition), and that they are also little related to the two control scales. If anything, there is a slight tendency for the CRM scales to be <u>inversely</u> (if only modestly) related to the control scales. That means there is a <u>slight</u>, but believable, tendency for scale scores on the goal sharing scales to decrease as scores on the CRM attitudes increase. The patterns of intercorrelations found in Table 3 were replicated in intercorrelations between the Post-training survey and the 2-month, 6-month, and 12-month Follow-up surveys.

RESULTS SECTION 1:

COMPARISON OF ATTITUDES

All available survey responses are used for the initial comparisons to follow.

Comparison Of This Company's Maintenance CRM With Other Companies'

The Technical Operations managers and staff professionals in the present company were very enthusiastic about this CRM program after they had experienced it. This is clear examining their post-training responses to two questions, dealing with their general reactions to the CRM program, and comparing them with answers to the same questions (also following CRM training) in another Maintenance Department and in Flight Operations in other companies. One of these questions asked, "How much will the [CRM] training change your behavior on the job?" (*cf.*, Appendix B1, Q28). The other question asked, "How useful will the [CRM] training be for others? (*cf.*, Appendix B1, Q27). Figures 1 and 2 present comparisons for the two questions, respectively.

FIGURE 1

"Is The Training Going to Change Your Behavior On The Job?" (Post-Training Survey)
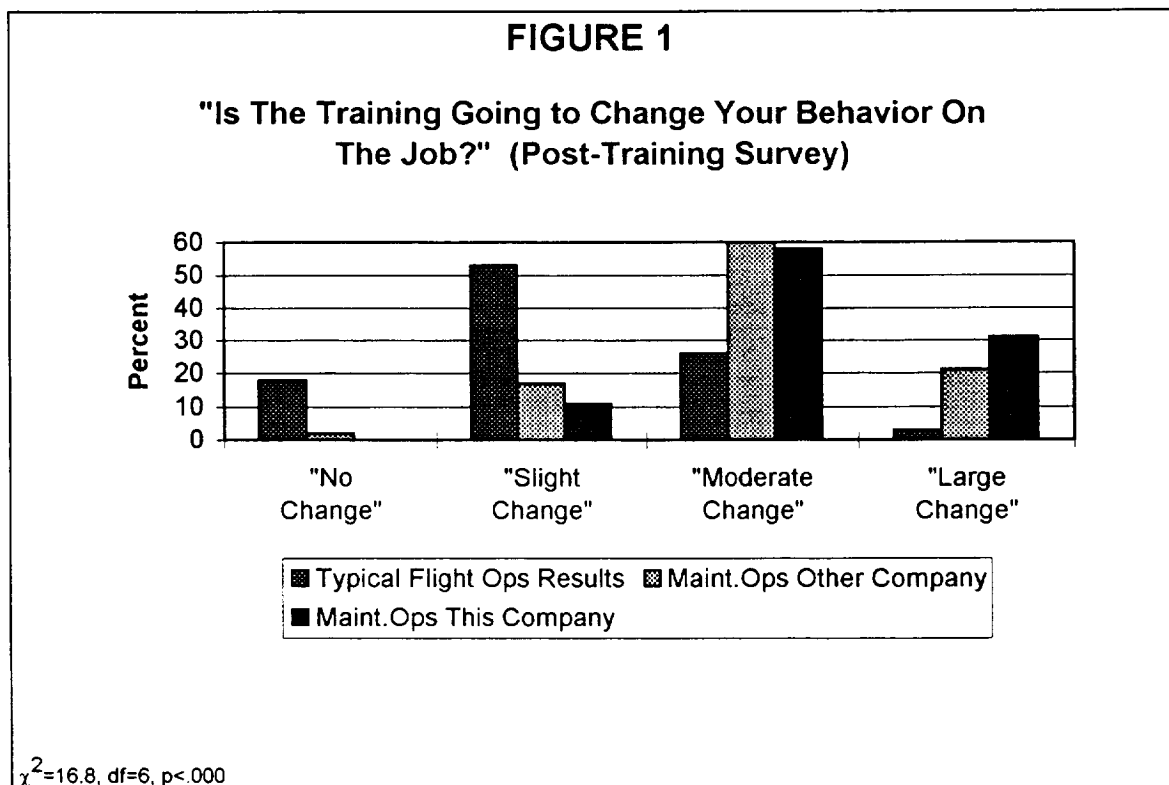
χ^2=16.8, df=6, p<.000

Figure 1 compares the post-training survey respondents from the present study, on the amount of predicted behavior change, with post-training answers to the same question from a typical Flight Operations sample (Helmreich, 1989), and from another airline's Maintenance department sample (Taggart, 1990). The present Technical Operation's organization shows a very high level of predicted behavior change (nearly 90% say either "moderate" or "large change." The other Maintenance organization is also very high on

15

the question (over 80% say "moderate" or "large change"), while the typical Flight Operations sample is considerably lower on this item, with only 30% predicting "moderate" or "large change." Both maintenance groups are seen to regard CRM training as having a very strong potential for personal change.

FIGURE 2

How Useful Will This CRM Training Be For Others?

■ Flight Ops Company A   ▨ Flight Ops Company B
■ Maint. Ops Company C   ▢ Maint. Ops This Company
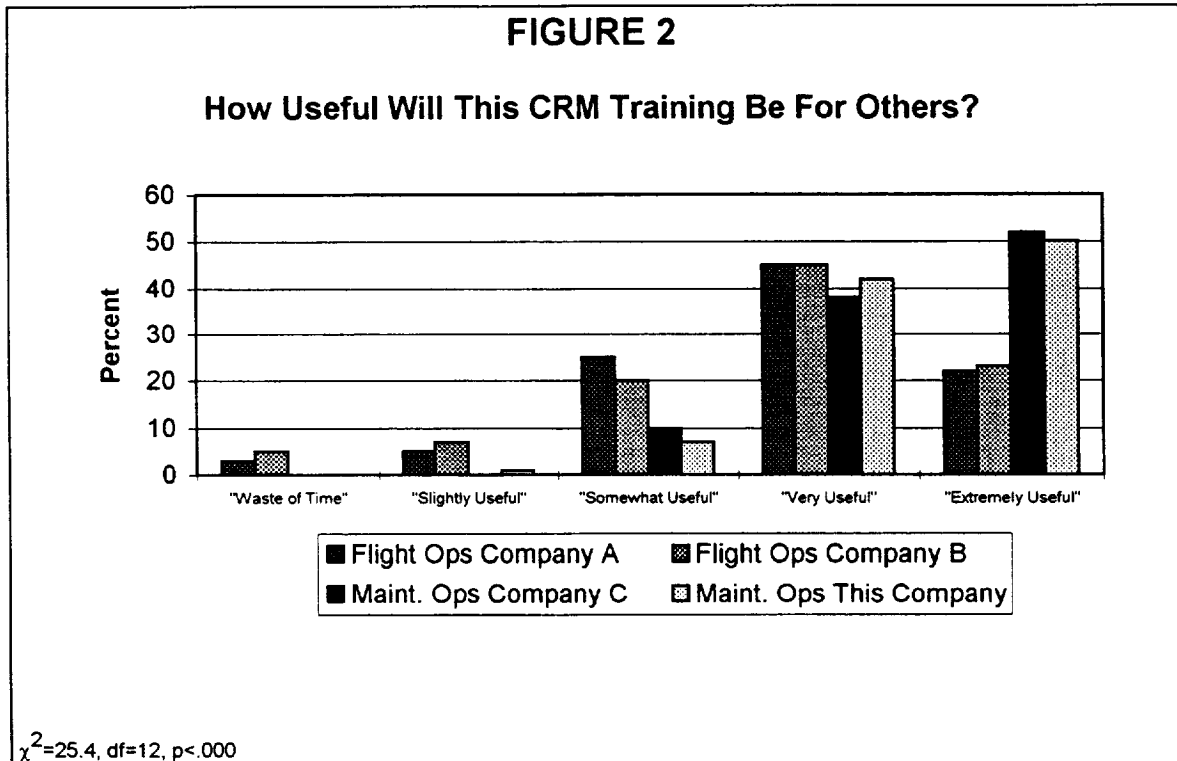
χ^2=25.4, df=12, p<.000

Figure 2 reveals great enthusiasm for CRM by both flight operations and maintenance participants immediately following their training. Nearly two-thirds of both flight operations samples, shown here, report feeling that the CRM training was "very" or "extremely useful" for others. Those Flight Operations samples (Helmreich, 1989) show a strong belief in CRM training, but the results to the same question using two maintenance samples are even stronger. Ninety percent of Taggart's maintenance respondents, and a similar proportion from the present sample, reported that their CRM training was either "very useful" or "extremely useful."

Comparison Of This Company's Maintenance CRM Over Time
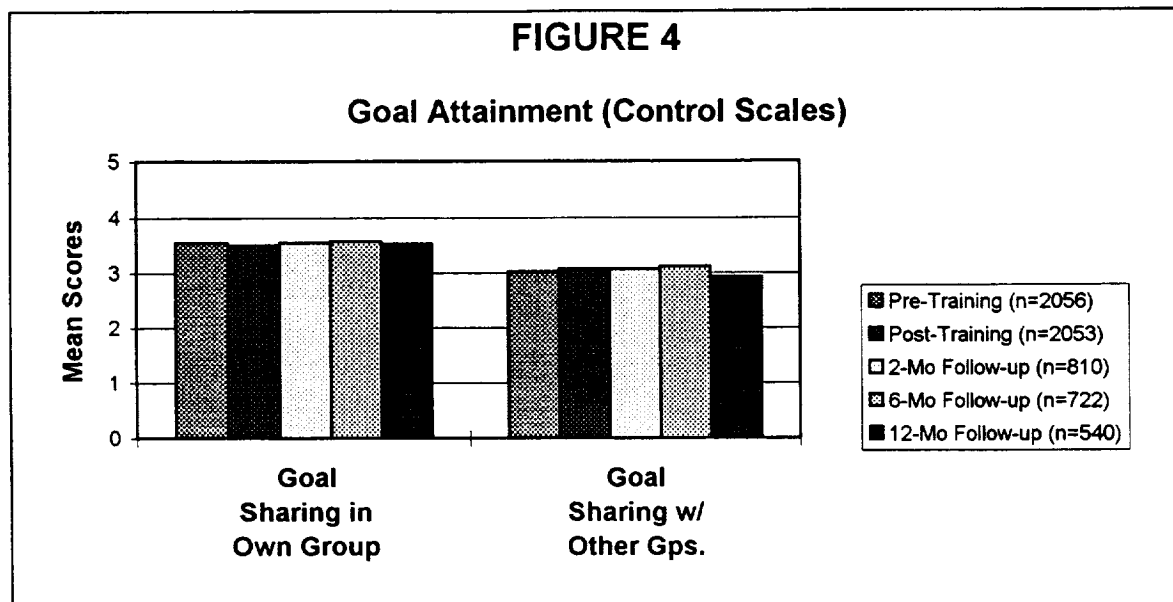
Attitude change from pre-training to post-training surveys. Results using all respondents who completed the CRM/TOQ immediately before and immediately after training demonstrated that many of the intended effects on participants' attitudes were achieved. Figure 3 presents the pre, post, 2, 6, and 12 month comparisons for the four attitude scales using all responses.

FIGURE 3

CRM Attitude Scales
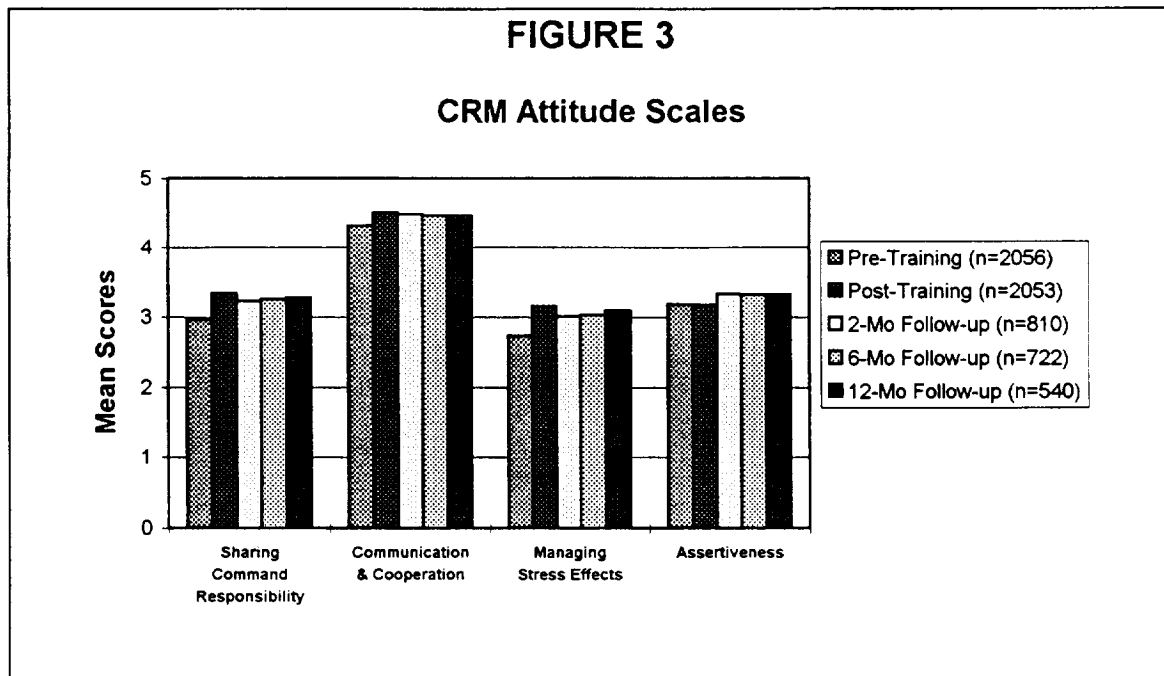
The attitude index scores for "Sharing Command Responsibility," "Communication & Coordination," and "Managing Stressor Effects," all increased immediately following training. A Multiple Analysis of Variance (MANOVA) "F" was used to test the differences among same-scale values for the pre- and post-training surveys and established that the pre-post differences noted were statistically significant ($F=6.77$, $df = 2156$, 4; $p<.000$). "Willingness to Voice Disagreement," a measure of assertiveness and a central topic of the training, did not increase significantly immediately after the training.

Attitude change in follow-up surveys. Once again the MANOVA "F" statistic was used to test the differences among the same-scale values for the four surveys taken subsequent to the training. With one notable exception, there were no significant differences found among the post-training, two, six and 12-month surveys. That exception is the assertiveness scale, "Willingness to Voice Disagreement," which increased significantly between the post and 2-month surveys ("t"= 2.16, df = 2,158, p<.04). All four attitude scale scores remained high thereafter over the remaining period.

Change in the Control Variables for the Pre-Post and Follow-up surveys. The two "Goal Sharing" measures were also compared over the same time period as the four attitude scales. The goal sharing scales were not expected to change as a result of the CRM training. Although goal setting and attainment are important aspects of maintenance work, the training was not designed to directly influence either attitudes or perceptions about that aspect of management. Figure 4 presents the pre, post, 2, 6, and 12 month comparisons for the two goal sharing scales using all responses. The MANOVA "F" test was applied to these data and was found not to be statistically significant (F=1.29, p>.05,df = 2156,4).

17

FIGURE 4

Goal Attainment (Control Scales)

Legend:
- Pre-Training (n=2056)
- Post-Training (n=2053)
- 2-Mo Follow-up (n=810)
- 6-Mo Follow-up (n=722)
- 12-Mo Follow-up (n=540)

X-axis categories: Goal Sharing in Own Group; Goal Sharing w/ Other Gps.

Y-axis: Mean Scores (0–5)

Matching Questionnaire Responses Over Time

Matched questionnaires and sample size. For the remainder of the analyses in this report the results for the CRM/TOQ will be reported in terms of the largest number of individual surveys received after training that could be **matched,** by I.D. code, to their pre-training counterpart.

CRM training participants were asked to include a confidential identification number on the top of their pre-training questionnaire and to write that number on the front page of their training notebook. They were encouraged to invent a six-digit number known only to them to ensure complete confidentiality. The participants were alerted that they would be asked to use the number again on a similar questionnaire at the completion of the training, as well as three more questionnaires which would be mailed to them in the months to follow. This I.D. number, it was explained, would be used over the times sampled to compare answers respondent by respondent rather than merely by groups over the four time periods. Participants were assured that the numbers they chose were not intended to identify or single out individuals, but merely to match earlier answers on the questionnaires with later ones. They were also told that this questionnaire, and all others to follow, would be sent directly to the University for processing, tabulating, and summarization.

Rationale for the "matched respondents" sample. Using a matched sample insures the comparisons made over time are made with the same core group of people, which provides added validity to the time-lagged results obtained. One practical cost of this matching is that the size of the matched sample for each of the three follow-up surveys is reduced, over the total, by the number of respondents who did not include a recognizable code with their completed questionnaire. The benefit of using such a sample, however

18

clearly outweighs the penalty of a reduced sample size. Using matched respondents over time guarantees that a work group's average attitude scores, compared over time, will be drawn from the same sample. There need be no concern that differences found over time are the result of comparing respondents who are incomparable with one another.

Table 4 displays the number (and percentage) of respondents whose later answers could be matched with their answers to the previous questionnaires. For the analyses included in this report the sample used is of respondents whose subsequent answers were matched to their pre-training responses. Table 4 shows that sample, matched to their pre-training responses (shown in the upper row in Table 4), to include between 74% and 88% of the total responses available.

TABLE 4
Numbers of Questionnaires Matched with Previous Surveys

	Post-training Survey (n=2,053)	2 Month Follow-up Survey (n=810)	6 Month Follow-up Survey (n=722)	12 Month Follow-up Survey (n=540)
Matched with the Pre-training survey (n=2,056)	1,822 (88%)	598 (74%)	548 (76%)	415 (77%)
Matched with Post-training Survey (n=2,053)	-	561 (69%)	520 (72%)	387 (72%)

Testing for differences among the matched samples, over time. The demographic characteristics for the post-training sample, and the three follow-up samples were compared with one another, in order to test for possible differences in the composition of the four groups. Table 5 presents those comparisons for age, occupation, department, education and prior experience.

TABLE 5

Demographic Comparisons Among the Four After-Training Surveys

Demographic Item	Post-tng. Survey	2 Month Survey	6 Month Survey	12 Month Survey	Statistical Test	Significance Level
Job Title (9)						
Engineers	6.6%	8.8%	9.3%	12.4%	χ^2=82.4	.000
Inspectors	9.6%	3.8%	3.5%	1.8%	df=24	
Department (8)						
Engineering	7.1%	9.3%	10.8%	13.1%	χ^2=51.0	.000
Qual. Cont.	11.3%	7.3%	6.7%	6.6%	df=21	
Location (City = 14)	n/a	n/a	n/a	n/a	χ^2=28.6 df=39	ns
Mean Age in years	42.0	43.0	42.5	43.9	"F" = 3.73 df=3, 3220	.001
Education						
Mean years College	5.7	5.2	6.3	5.7	"F" = .29 df=3, 3196	ns
Mean years Trade Sch.	5.1	4.4	5.5	4.9	"F" =.32 df=3, 3242	ns
Military Exp., Mean Years	6.1	5.7	6.5	6.3	"F" = .18 df=3, 3327	ns

Age, years of education, and years experience were tested using the ANOVA "F," while the differences among the four survey samples on occupation, and department (being categorical or "nominal scale" data) were examined using the "chi-square" (χ^2) test. Of all the tests performed for these data, only age, occupation and department were found to show significant differences among the four time samples. Not unexpectedly, the average age of the matched sample increases from 42 years at the time of training, to almost 44 years at the last follow-up survey. Because many 12 months surveys were sent out late and delays were seen in their return, this increased age doubtless reflects the mere passage of time. Closer examination of the results for occupation revealed that of all the occupations a disproportionately large number of Engineers, and small number of Aircraft Inspectors, are found in the 12 month sample when compared with those occupations' in the post-training survey. Likewise, for the test of differences among departments show that Engineering Department and Quality Control (the Inspectors' department) to show disproportionately higher and lower numbers, respectively, at 12 months following their training. Given that Engineers and Inspectors, together, account for only 16-18% of the total sample of matched respondents, the effect of their over and under-sampling at 12 months is unlikely to affect the overall results reported below.

Number of work units represented in the "matched sample." The total of all 1,822 matched respondents in the post-test sample, includes the members of over 50 organizational units drawn from all parts of Technical Operations: (Supply, Quality, Base

Maintenance, Line Maintenance, Shops, Stores, Materials, Engineering, Planning, and Administration). The total numbers of units in each analysis vary depending on the specific performance indicator, because not all the work units are measured for the same performance. These differences are described in the following section.

RESULTS SECTION 2:

TRENDS IN MAINTENANCE PERFORMANCE

BEFORE AND AFTER THE ONSET OF CRM TRAINING

Performance Data Described

Maintenance managers in the company collected performance data in abundance. Table 6 presents the five measures used as end-result criteria in the present study.

TABLE 6
Performance Measures Selected for Test

PERFORMANCE MEASURES	MAXIMUM WORK UNITS MEASURED	RATED SENSITIVITY (1 = most sensitive to trng)
SAFETY		
Aircraft Safety (number of maintenance-related ground damage incidents per flight)	38	1
Occupational Safety (lost time injuries, per 1000 hours)	55	1
DEPENDABILITY		
On-time Departures (% departures w/in 5 minutes of schedule)	31	1
On-time Maintenance (delays due to late from planned maintenance, per 100 scheduled aircraft)	35	1
EFFICIENCY		
Contained Overtime Cost (% overtime paid to total wage bill)	55	2

Three conditions were met in order to include these measures in the work-unit analysis reported here. First (and obviously) the performance measures need to be available by work unit (i.e., line station, shop, warehouse, etc.), and not just by department or function. Second the measures must be ones that people in the work unit can affect by their actions,

or can effectively adapt to; and not merely ones that are conveniently assigned to a unit, but for which little can be done. The third condition applied was that the measures not be directly related to (or completely determined by) other measures in the set. The five performance measures used in the present analysis are included in the company's categories of "safety," "dependability," and "efficiency." "Quality" measures used by the company are available only for the whole department. Because they cannot be applied to the specific maintenance units, quality measure are not included in this present analysis.

The trainers and administrators of the CRM course evaluated all the available performance measures and predicted which of them would be more sensitive to effects of CRM training. Their conclusions were that four measures would be the most readily improved by the training. These four performance measures included the two safety items "ground damage" and "days lost to occupational injury;" and two dependability measures, "flight departures within 5 minutes," and "delays in 'scheduled work' (e.g., overnight repairs, and overhaul) due to "maintenance error". Their lower ranked performance measures in responsiveness to training included the efficiency measure of "overtime paid."

Performance Rates and Trends Before and After the CRM Training Began.

The "before" and "after" scores for the five performance measures were plotted, and their trends compared over the time period for which measures were available.

Measures of Safety Performance: Safety of Aircraft and Personal Safety. Figure 5 presents before-and after-training comparisons of number of Ground-Damage incidents for 38 work units.

FIGURE 5
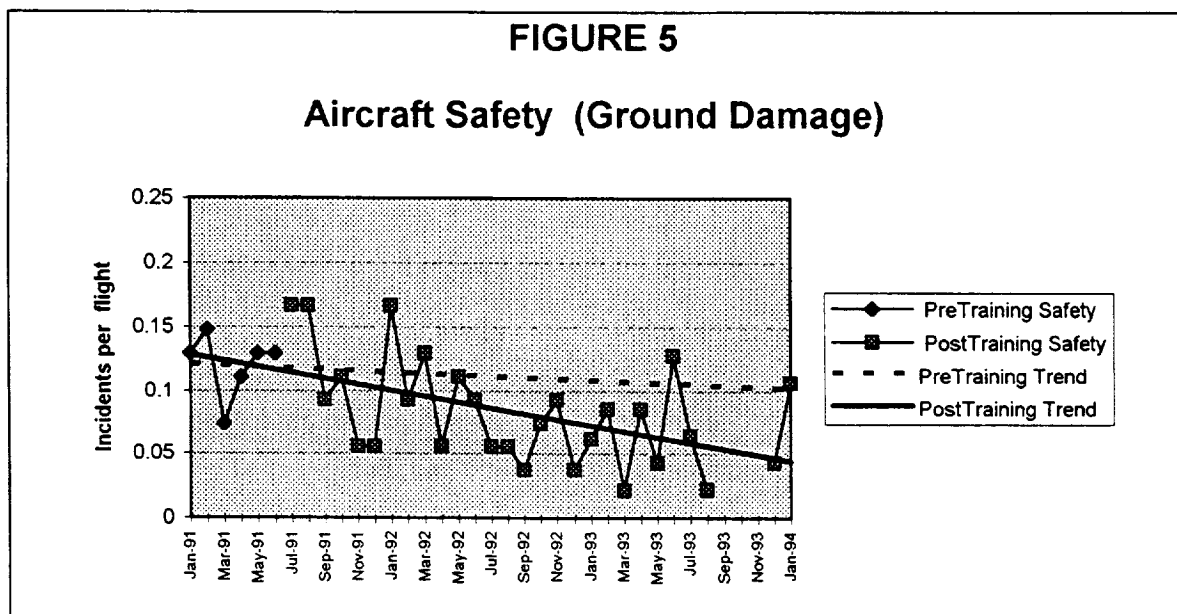
Aircraft Safety (Ground Damage)

22

Figure 5 shows a strengthening of the trend for the decreased number of ground damage incidents (measured in incidents per flight), for the 30 months (for which there were data available) after the CRM training began, when compared with the six months before. The reduced rate for ground damage incidents appears to be related in time to the CRM training.
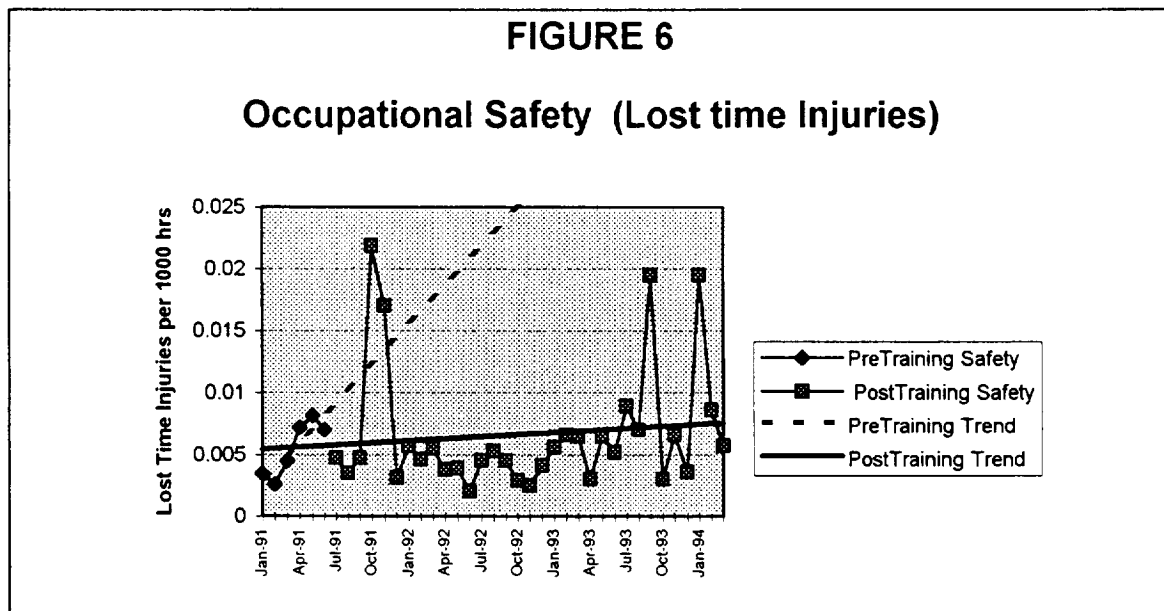
FIGURE 6

Occupational Safety (Lost time Injuries)

Figure 6 shows the rate of lost time injuries, per 1000 hours worked, for 55 work units..In Figure 6 we see a dramatic shift in trend for occupational injury rate comparing the six months of pre-training performance with the period afterwards. Closer examination of Figure 6 also shows that, except for the unusual (and unexplained) "spike" in the fourth and fifth months after the onset of training, the injury rate remained at a low level for a year and a half after CRM training was introduced. Following January, 1993, the injury rate begins to edge up slightly and then it spikes in September 1993 and again in January 1994. Both of those spikes are caused by unusually high rates from individual maintenance stations which had been notified that they were scheduled to close. A reasonable assumption is that the impending closures affected mechanics' morale which in turn affected their attention to personal safety. Results from Figure 6 thus suggest that the CRM training caused behaviors leading to greater safety for at least 18 months, until other events (e.g., site closures and reductions in force) overwhelmed the training's overall positive effects.

23

Measures of Dependability. Figure 7 presents before- and after-training comparisons for "Departures within 5 minutes of schedule" for the 31 line maintenance stations for which this measure is relevant.

FIGURE 7

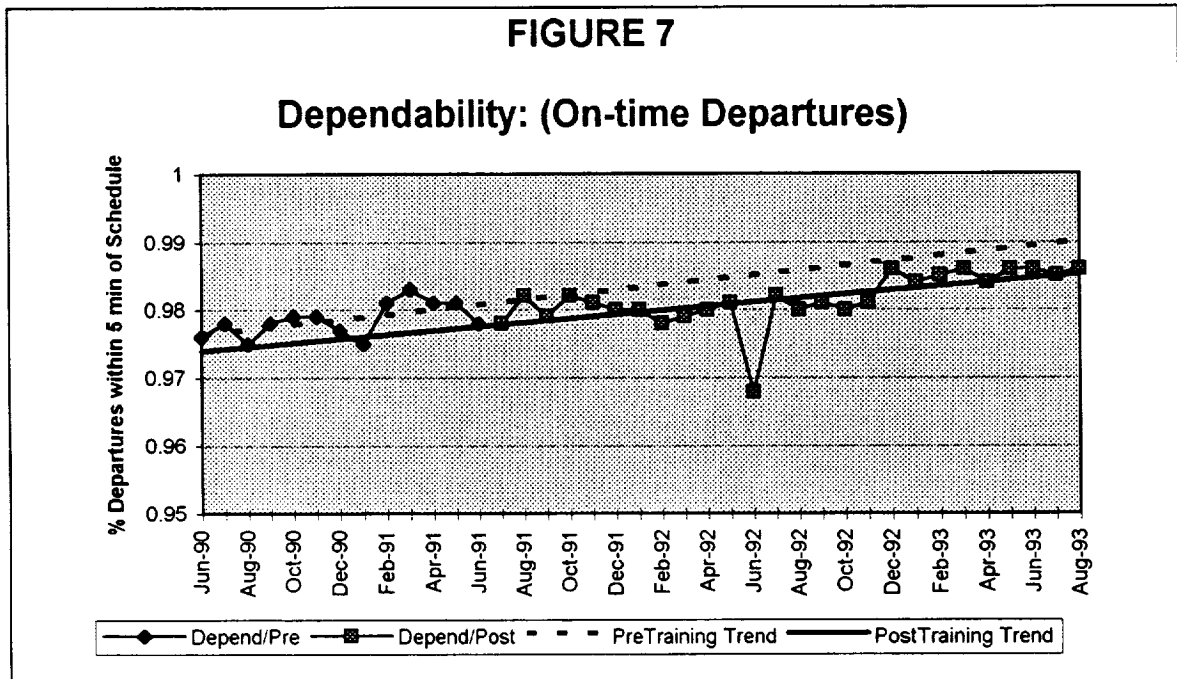### Dependability: (On-time Departures)

Figure 7 demonstrates that line maintenance responsibility for on-time departures continues to steadily improve both before and after the training began. Although the performance was trending up in the period preceding the training, this chart shows a higher level of performance, overall, at the end of the second year following the onset of CRM training.

Figure 8 shows before and after comparisons for the other indicator of dependability, "On-time planned maintenance" -- measured by the number of aircraft delays due to late from scheduled (or planned) maintenance -- for 35 work units (including line and heavy maintenance stations).

FIGURE 8

Dependability: Late from Planned Maintenance
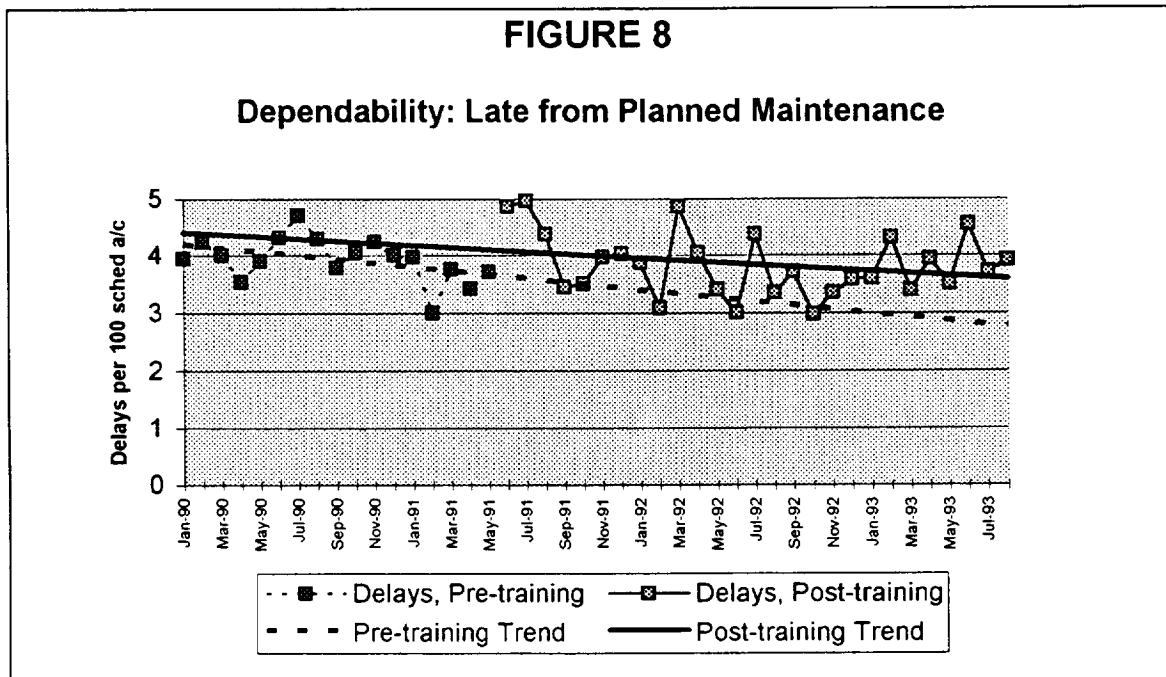
Although the overall rate for "On-time maintenance" (i.e., delays due to being late from scheduled maintenance declining) continually improved over the period measured, no appreciable change in that rate is noted in the years following the onset of CRM training, when compared with the period before the training began.

Measure of Efficiency. Figure 9 shows the pre-post comparisons for the percentage of hours of overtime charged for the 55 work units measured.

FIGURE 9

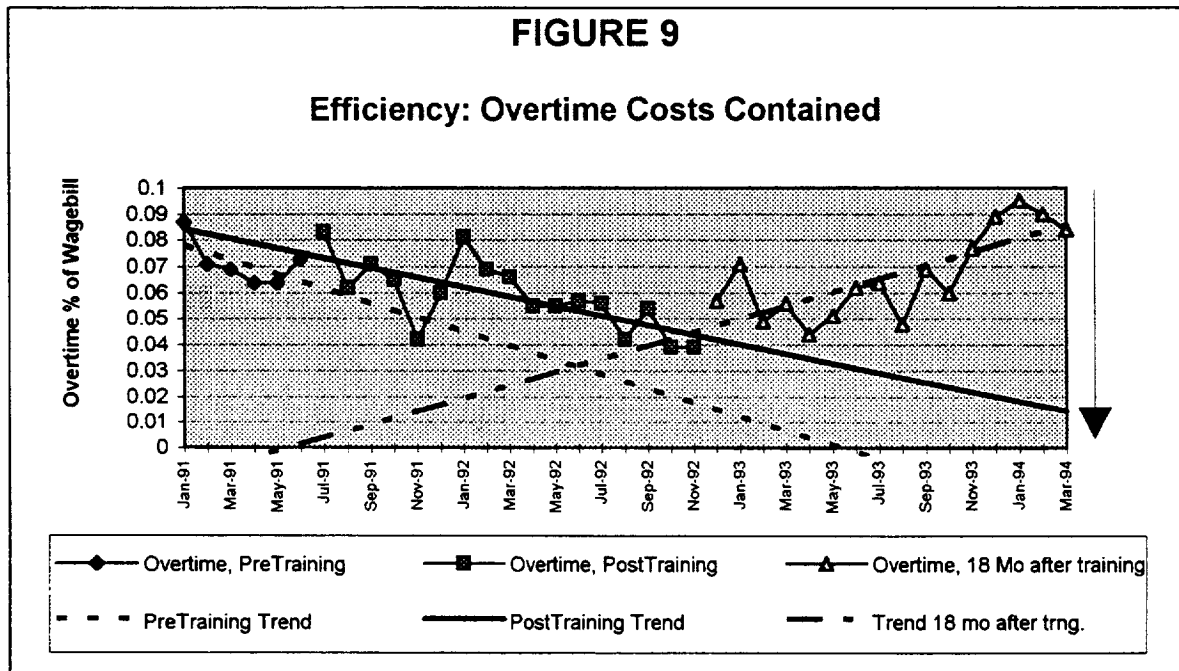**Efficiency: Overtime Costs Contained**

Figure 9 shows that the trend of overtime expenses for the 16 months following the onset of CRM training continues the rate of improvement, but that trend then reverses from December, 1992 for the remaining 16 months for which we have data. The initial improved cost performance appears coincident with the training, and may be affected by it. An alternative explanation is that these rates were more affected by top management policy in 1991 and 1992, which at first sustained tight controls on overtime expenses, and then undertook a labor force reduction which necessarily increased hours for the remaining staff. Further analyses below examine this possible effect of changed policy and of CRM-related skills used in coping with it.

RESULTS SECTION 3:

Testing Relationships Between Attitudes and Performance

The data sets used in the attitude-performance analyses. There were five data sets used for the attitude-performance analyses. By the completion of the current phase of the CRM training, in March, 1994, 1,822 of the 2,199 participants attending one of the CRM workshops had completed questionnaires such that they could be included in the "matched samples" of the pre-, and post-training surveys as well as being the basis of the matched 2,

6, and 12 month follow-up surveys. Of those 1,822, 1,692 participants had also provided valid departmental identification and, thus, could be included in one of the five data sets. The first of those data sets was comprised of 395 participants who were employed in the Technical Operations department's Line Maintenance division. Attitudes from those 395 Line Maintenance participants in 31 work units are tested against the Line Maintenance measure of *"On-time departures."* For the second data set, Base Maintenance division added another 266 participants (in 4 hangar locations), which together with Line Maintenance participants provides a total of 661 training participants (in 35 work units) for the source of attitude data examined in relationship with the maintenance measure *"On-time maintenance."* The third data set added another 477 (in three more city-site locations) from the Technical Operations department's direct support divisions, of Quality Control (n=192), Prime Shops (n=111), and Materials Service (n=174), to test the performance measure *"Aircraft safety."* That third data set is composed of 1,138 maintenance and support personnel in 38 work units. For the fourth and fifth data sets, participants in the remaining Technical Operations units for Planning (n=194), Engineering (n=120), and Administration (n=240) were added to the data sets above for a total sample of 1,692 participants in 55 work units. These samples were used to test attitudes against the performance measures of *"Occupational safety,"*and *"Overtime costs contained."*

  The correlation statistics used in the present analysis. The relationships between the attitude indices and the performance measures, summarized in Tables 7-11 below, were calculated using the Spearman Rank-order Correlation statistic ("Rho," or ρ). The use of Rho is advisable in this case because the distributions of these five performance measures narrow the choices to non-parametric statistical tests for optimal analytic power (Taylor, 1991b). The measured results of four of the five performance measures are "improving" when they decline numerically (i.e., the absence of delays due to late from planned maintenance, the absence of occupational injuries, the absence of ground damage incidents, and reduction of overtime costs). To simplify the presentation of findings all results in Tables 7-11 are described as postive coefficients when the original correlations are in the expected direction (i.e., favorable attitudes equal better performance).

  Longitudinal relationships between performance and attitudes. A part of the following analysis examines the potential impact of performance prior to the CRM training on participants' subsequent attitudes. The more central part of the evaluation of CRM training however, is the analysis of those attitudes' effects on subsequent maintenance performance. We are interested mainly in the latter analysis -- the CRM training's longer-term effects on attitudes, and their lagged effect on performance following the training.

  In Tables 7-11, to follow, the larger percentages, of 1/3 (33%) or greater, are boldfaced as a visual aid.

Correlations Without Training Effects

  The relationships between the pre-training questionnaire scales and maintenance unit performance measures. The first associations examined here are the four pre-training attitude scales (measured at the beginning of each training session) with the five

27

maintenance performance indicators. Table 7 contains the percentages for statistically significant correlations between each of the four attitudes and each of the five performance indicators.

TABLE 7
Percentage of Significant Correlations
Between Pre-training Attitudes and Performance

| | Pre-Training Attitude Scales | | | |
	Sharing Command Responsibility	Communication & Coordination	Managing Stress Effects	Assertive- ness
Dependability				
Departures within 5 min of schedule				
13 months before training	40	40	33	20
26 months after training	33	40	11	15
On-time maintenance				
17 months before training	6	39	0	6
27 months after training	0	40	7	15
Safety				
Occupational Safety				
5 months before training	40	40	20	0
33 months after training	6	68	3	24
Aircraft Safety				
5 months before training	0	40	0	20
28 months after training	6	13	10	3
Efficiency				
Overtime paid				
5 months before training	0	20	0	0
33 months after training	42	11	15	21

Table 7 shows that the pre-training survey attitude scale "Communication & Coordination" has a large number of statistically significant relationships with four of the five pre-training performance indicators. That means that good performance before the CRM training began was quite widely related to positive pre-training attitudes about communication & coordination. That pre-training scale measuring communication & coordination attitudes was widely related to post-training dependability and occupational safety as well. Taken together, these results suggest that although communication and coordination is an important value to managers and professionals in the most effective units, CRM training may not be a crucial intervention for this effect. This communication and coordination scale had a remarkably high initial mean score (cf., Figure 3), which suggests the possibility that the scale may contain a "social desirability" bias. "Communication and cooperation" is also quite a general concept and can have vague or multiple meanings. It is also a somewhat "passive concept," because its constituent

28

questions have fewer specific behavioral references than the other more specific attitudes measured with the CRM/TOQ.

FIGURE 10

Correlations between: Pre-Training Attitude "Communication & Coordination," and Selected Performance Indicators

☐ Aircraft Safety (n=38)　　■ Occupational Safety (n=55)　　☐ On Time MX (n=35)　　☐ On Time Departures (n=31)
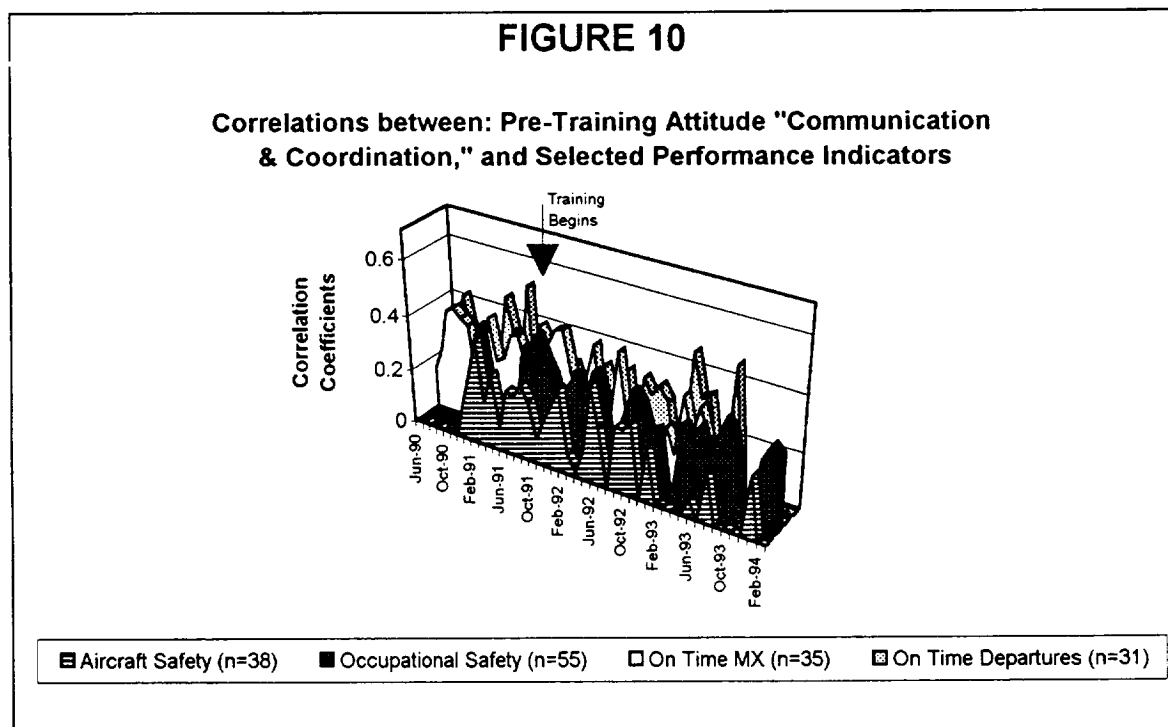
Figure 10 plots all of the individual correlations between "communication & cooperation and the four performance indicators most related to it. Figure 10 reveals a large number of months in which the correlations between that attitude and the four performance measures are as high as .40. Over time some of those correlations, particularly for aircraft safety and on-time maintenance, decline in size. It was reported in Table 7 that "communication & coordination" were related to "aircraft safety" in 40% of the months measured before training began in June, 1991. To illustrate this, in Figure 10, aircraft safety is shown as the first profile of the four. Two of the five correlations (40%) before the training began in June 1991 are greater than .25, which is statistically significant at the p=.05 level of confidence for a sample of 38. That profile of relationships between communication & coordination and aircraft safety demonstrates than the correlations are higher and proportionately more numerous before the training began, than afterwards.

Table 7 also reports that another pre-training attitude with many significant correlations with performance is "Sharing Command Responsibility." This attitude scale is seen to be frequently related to line station dependability ("departures within 5 minutes of schedule") both before and after training began. This pre-training attitude about delegation is also related to containing subsequent overtime costs. Figure 11 displays all

29

the correlations between the pre-training attitude toward sharing responsibility, and overtime costs.

FIGURE 11

Correlations between: PreTraining Attitude about Delegation, and Overtime Costs Contained
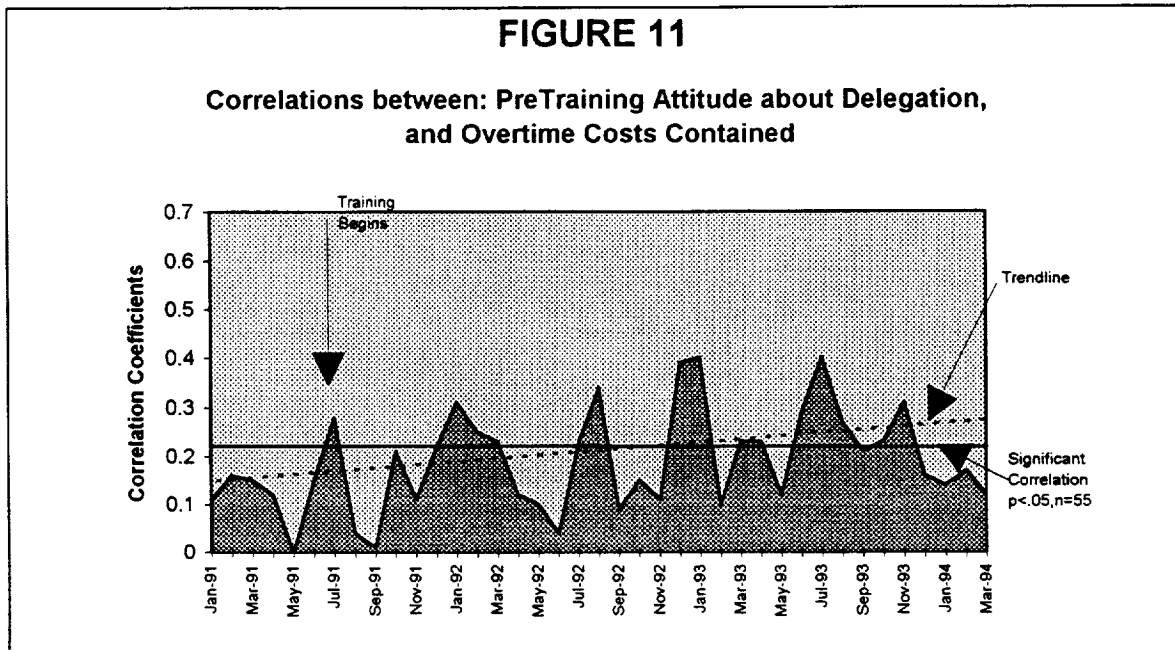
Figure 11 is a more simple two-dimensional presentation than Figure 10. This simplicity allows for the inclusion of a solid line showing the level of significance ($\rho = .22$, $p < 5\%$) for this performance measure using the 55 work units available for this series, and a dotted trendline (calculated by the least-squares regression method) for the correlation coefficients over time. Figure 11 shows that of the 33 months of overtime measured after training began, 14 of them (42%) had correlations above the significance level. Furthermore, the trendline in Figure 11 shows an upward slope which confirms that the correlations between pre-training feelings about participation ("sharing responsibility") and subsequent coping with restrictive overtime policy become more strongly related over the period, June 1991 to March 1994. The results in Figure 11 clearly show that managers and staff professionals who hold more participative values before they attended training are subsequently successful in coping with overtime costs. Whether the CRM training can impact to further increase that value will be tested below.

Correlations Showing Training Effects

The remaining Tables, 8 through 11, report the proportion of relationships between the questionnaire scales obtained after the CRM training and maintenance unit performance measures.
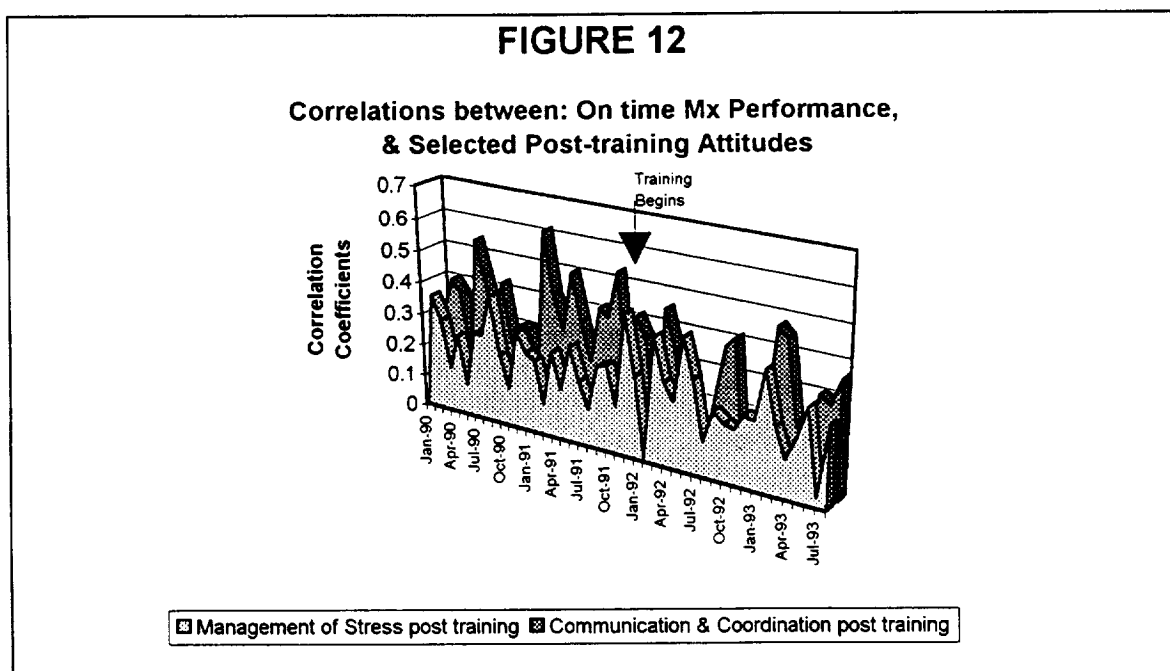
Table 8 displays the percent of significant correlations between attitudes obtained from the post-training survey and the five performance items.

TABLE 8

Percentage of Significant Correlations
Between Post-training Attitudes and Performance

	Post-Training Attitude Scales			
	Sharing Command Responsibility	Communication & Coordination	Managing Stress Effects	Assertive-ness
Dependability				
Departures within 5 min of schedule				
13 months before training	0	58	17	17
26 months after training	7	29	17	4
On-time maintenance				
17 months before training	6	53	41	24
27 months after training	7	33	37	22
Safety				
Occupational Safety				
5 months before training	20	20	0	0
33 months after training	9	3	3	18
Aircraft Safety				
5 months before training	40	0	20	0
28 months after training	3	9	3	3
Efficiency				
Overtime paid				
5 months before training	40	0	0	0
33 months after training	18	3	12	3

Improved attitude about "sharing command responsibility" is seen in Table 8 to be related to preceding months of good aircraft safety (lower damage) and lower overtime costs. These results suggest that the CRM training's immediate positive effect on attitudes about participation cannot be credited with subsequent performance. Table 8 also shows that the post-training attitudes about "communication & coordination," and the "value of stress management," are both very frequently related to on-time scheduled maintenance performance both prior to and after the training began. As noted above, the attitude scale measuring "communication & coordination," may be subject to some "social desirability" bias, but it is apparently also sensitive to the effects of the training. Because the attitude about stress management is lower overall before the CRM training, and the training specifically targeted improving stress management, it seems even more likely that the training has a direct effect on that attitude and can be credited with subsequent performance related to it. Thus, the number of significant correlations between stress management and performance for the months after the training began, are likely to be the result of CRM training.

Figure 12 displays all of the correlations between on-time scheduled maintenance performance and the two post training attitudes, "communication and coordination," and "stress managment," which are reported in Table 8. Figure 12 reveals that the pattern for correlations between the two attitudes, and pre and post training performance, is similar although communication & coordination has higher correlations before the onset of training, with on-schedule maintenance, than does stress management.

FIGURE 12

**Correlations between: On time Mx Performance,
& Selected Post-training Attitudes**

🖾 Management of Stress post training 🖾 Communication & Coordination post training

The relationships between the follow-up surveys and maintenance unit performance measures. Tables 9, 10 and 11display the percent of significant correlations between attitudes obtained from the 2-month, 6-month, and 12-month follow-up surveys, respectively, and the five performance items.
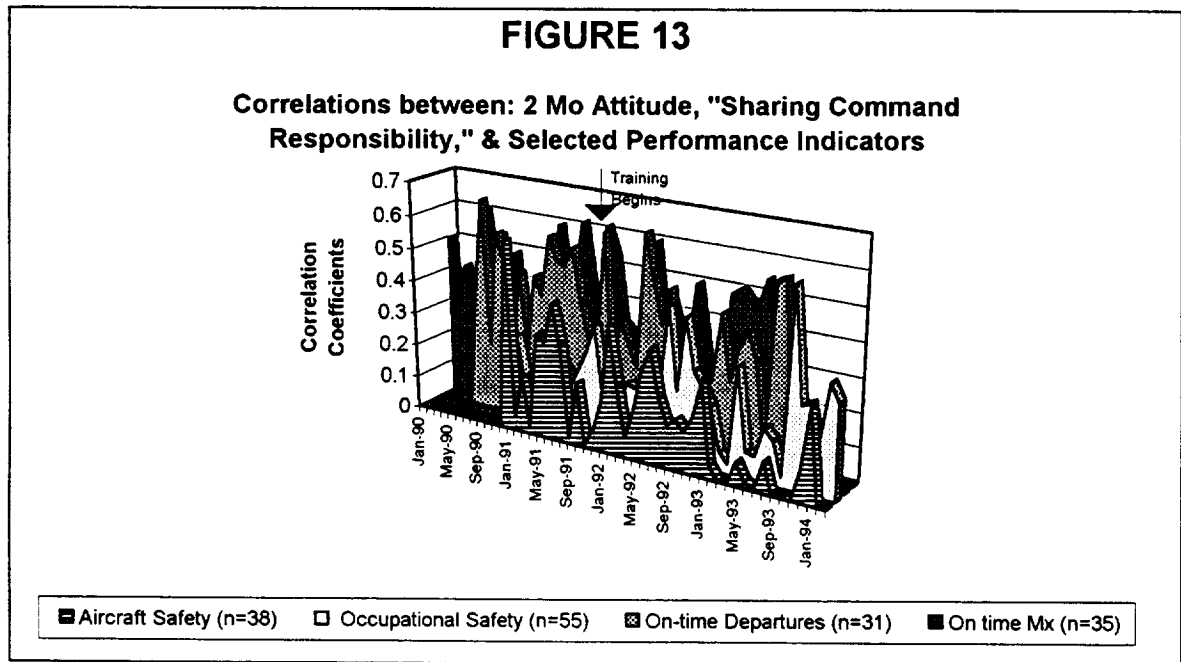
TABLE 9
Percentage of Significant Correlations
Between 2-Month Follow-up Attitudes and Performance

	2 Month Attitude Scales			
	Sharing Command Responsibility	Communication & Coordination	Managing Stress Effects	Assertive-ness
Dependability				
Departures within 5 min of schedule				
13 months before training	75	8	17	33
26 months after training	52	11	7	52
On-time maintenance				
17 months before training	65	0	0	0
27 months after training	78	4	4	11
Safety				
Occupational Safety				
5 months before training	20	20	0	100
33 months after training	32	3	9	62
Aircraft Safety				
5 months before training	40	20	20	20
28 months after training	29	4	14	21
Efficiency				
Overtime paid				
5 months before training	0	20	20	20
33 months after training	9	3	21	3

Table 9 displays the proportion of significant correlations between maintenance unit performance and attitudes from the follow-up survey obtained 2-months after training for those respondents with questionnaires matched to their pre-training survey. The more passive belief about "communication & coordination" was not found related to subsequent maintenance performance in this or in any later survey. Examination of these 2-month follow up results, reveals stronger relationships with performance, using attitudes about "sharing command responsibility," and the value of "assertiveness," than the immediate post-training survey showed. Both "sharing command responsibility," and "assertiveness," are "active" beliefs, the behavioral skills for which were emphasized in the training; and which require continued behavioral support, following the training, to reinforce them. Sharing responsibility, measured 2 months after training, shows a great many months of

significant correlations to post training performance for all dependability and safety indicators.

Figure 13 displays all of these correlations for the "command delegation" scale. Note how high many of the correlations are -- particularly with the two dependability scales (on-time departures, and on-schedule maintenance).

FIGURE 13

Correlations between: 2 Mo Attitude, "Sharing Command Responsibility," & Selected Performance Indicators

■ Aircraft Safety (n=38)   □ Occupational Safety (n=55)   ⊠ On-time Departures (n=31)   ■ On time Mx (n=35)

It is also reported in Table 9 that assertiveness is related to many (mostly subsequent) months of on-time departures, and occupational safety. Figure 14 displays these correlations between "assertiveness" two months after training, and performance.

FIGURE 14

Correlations between: 2 Mo Assertiveness Attitude, & Selected Performance Indicators

☐ Occupational Safety (n=55)   ▨ On-time Departures (n=31)
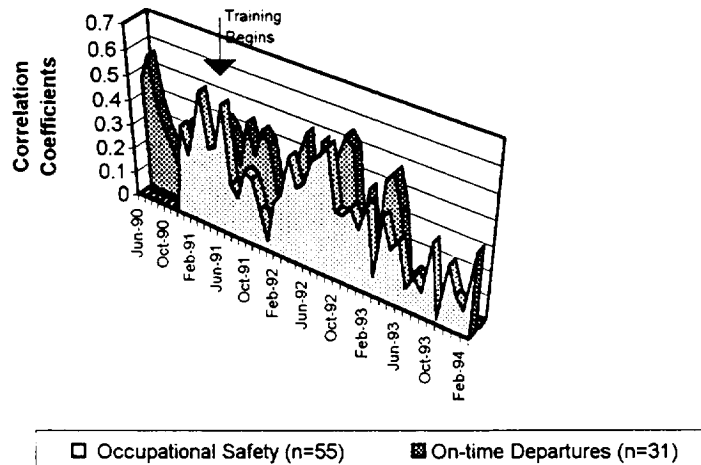
Overall, the results from this two-month follow-up survey are remarkably strong and suggest that lessons learned from the CRM training have consolidated by two months afterward and in the more "active" ways, especially in speaking up assertively.
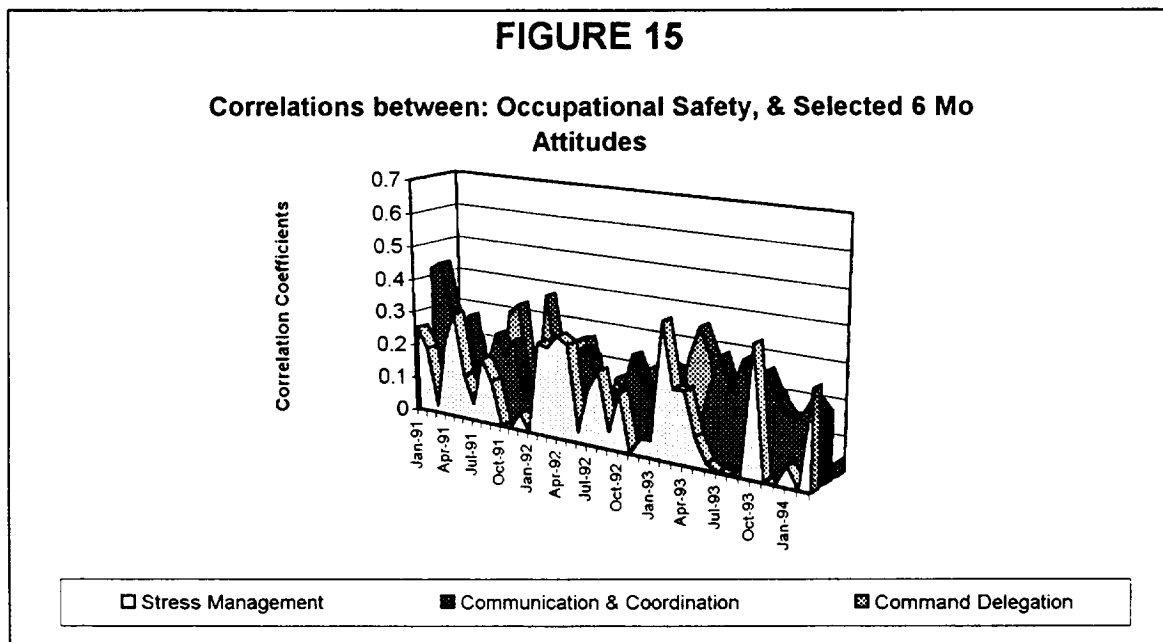
35

Table 10 displays the percentage of significant correlations between the attitudes measured six months after training and all available months of performance results.

TABLE 10
Percentage of Significant Correlations
Between 6-Month Follow-up Attitudes and Performance

	6 Month Attitude Scales			
	Sharing Command Responsibility	Communication & Coordination	Managing Stress Effects	Assertive-ness
Dependability				
Departures within 5 min of schedule				
13 months before training	16	42	0	0
26 months after training	4	26	0	0
On-time maintenance				
17 months before training	18	18	0	6
27 months after training	19	0	4	4
Safety				
Occupational Safety				
5 months before training	40	80	40	0
33 months after training	21	18	21	3
Aircraft Safety				
5 months before training	20	40	0	0
28 months after training	9	6	6	0
Efficiency				
Overtime paid				
5 months before training	0	20	20	20
33 months after training	9	3	21	3

These 6 months survey results show a lapse in the effects of CRM training compared with the 2-month follow-up survey. They reveal that only prior maintenance performance is related to opinions about delegation, communication, and stress management, surveyed six months after training. Pretraining occupational safety, was the only performance indicator widely correlated to three of the four attitude scales measured six months after training.

Figure 15 displays all the correlations for occupational safety and the three attitudes. Although a number of the correlations in Table 10 are statistically significant, most of them are lower in size than those seen for the two month follow-up survey in Figures 13 and 14.

FIGURE 15

Correlations between: Occupational Safety, & Selected 6 Mo Attitudes

□ Stress Management   ■ Communication & Coordination   ☒ Command Delegation

By the 12-month follow-up survey, the training effects have returned to mirror aspects of the post and 2-month surveys. Table 11 presents the percentage of significant correlations between the five performance measures and those attitudes.

TABLE 11
Percentage of Significant Correlations
Between 12-Month Follow-up Attitudes and Performance

	12 Month Attitude Scales			
	Sharing Command Responsibility	Communication & Coordination	Managing Stress Effects	Assertive-ness
Dependability				
Departures within 5 min of schedule				
30 months before survey	25	0	13	0
14 months after survey	7	0	13	7
On-time maintenance				
25 months before survey	6	6	23	0
14 months after survey	11	0	**52**	0
Safety				
Occupational Safety				
18 months before survey	35	12	18	**76**
21 months after survey	9	5	14	**68**
Aircraft Safety				
18 months before survey	6	6	12	0
16 months after survey	0	5	0	5
Efficiency				
Overtime paid				
18 months before survey	24	6	29	18
21 months after survey	27	27	**50**	5

According to Table 11, attitudes about the value of assertiveness one year after CRM training were related to a great many months of occupational safety both before and after that survey was taken. Attitudes, a year after training, toward sharing command decisions were (reminiscent of the 2 month results) also related to many months of occupational safety, but this time, in the months **before** the 12-month survey. Similar to the 2 month results, assertiveness attitudes were also related to many months of occupational safety performance. Figure 16 shows the correlations between occupational safety and the two 12 month attitudes "sharing command" and "assertiveness."

FIGURE 16

Correlations between: Occupational Safety, and Selected 12 Mo Attitudes

Command Delegation 12 months after training Assertiveness 12 months after training
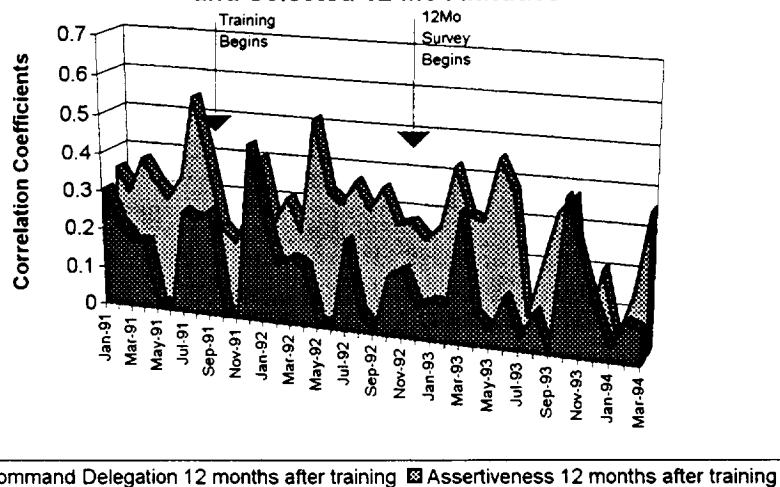
The results in Figure 16 show a reversal of the decline of training results in the six month follow-up. That continued improvement of relationships with attitudes after 12 months reflects further strengthening of the training effects. This suggests that the observed diminution of associations using the earlier, six month attitude data (*cf.*, Figure 15), represents an internal consolidation of training effects rather than their alleviation. In effect, maintenance managers and staff professionals recognized, in the months following CRM training, that their new knowledge and attitudes about participation was of value and that communication, and the effect of practicing the appropriate behaviors, could have an effect on their units' safety.

Another, very interesting outcome of the 12-month survey, reported in Table 11, were the relationships between managing stress effects and the many subsequent months of on-schedule maintenance, and overtime cost savings. These results follow June 1992, a full year after the onset of CRM training in June 1991. They represent performance for both of these very stressful requirements (holding to planned maintenance schedules and staying within required overtime levels) for an additional lagged period during which the lessons of stress management, learned during training a year earlier, had also consolidated for the training participants. Figure 17 presents the correlations between those stressful requirements and 12 month attitudes toward stress management.

FIGURE 17

Correlations between: 12 Mo Stress Management Attitude, and Selected "Stressful" Indicators

■ Overtime Costs Contained (n=55) ▧ On-time Maintenance (n=35)
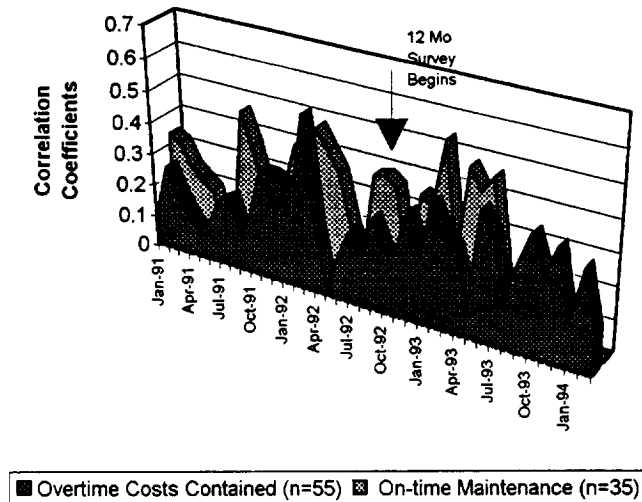
RESULTS SECTION 4:
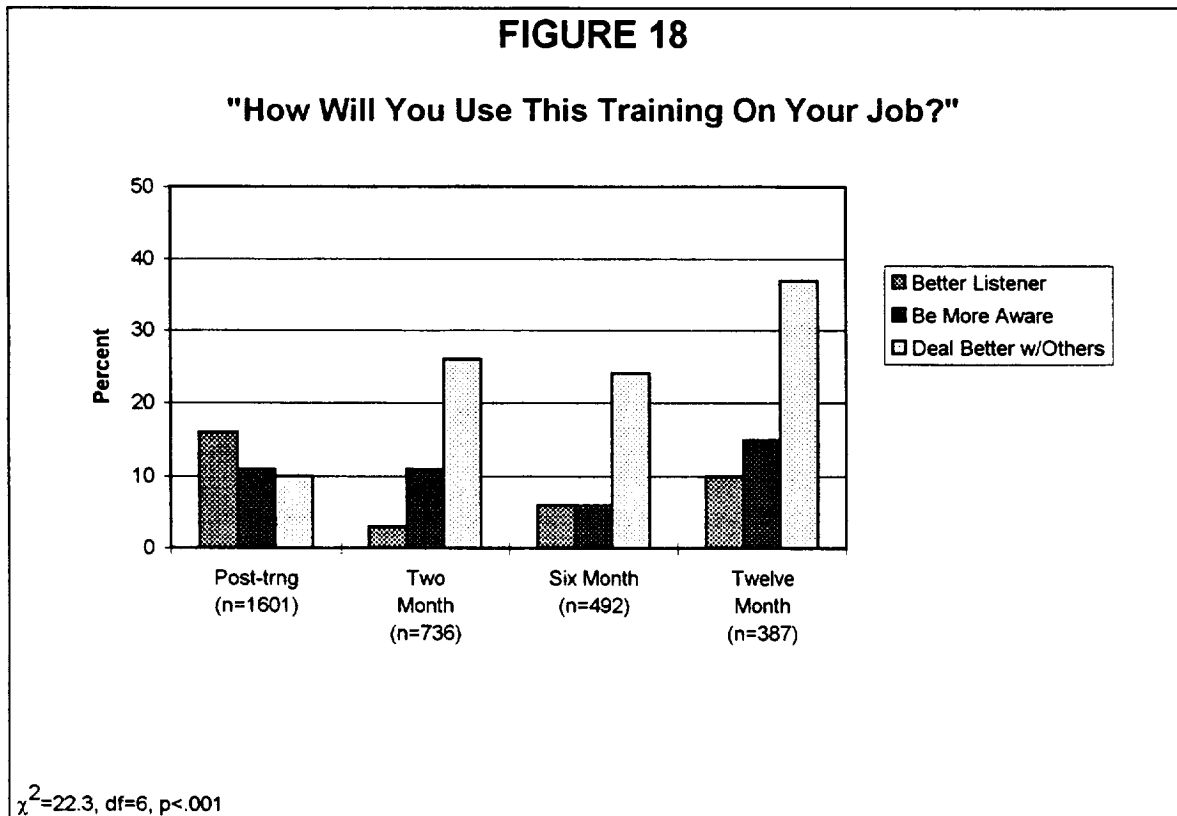
SELF-REPORTS OF BEHAVIOR CHANGE

Written Comments from the Post-Training and Follow-up CRM/TOQ

Two open-ended questions were asked of the maintenance CRM training participants concerning the intended use of the CRM training and its application to the job. We considered this type of question as a self-report of the perception of ones' intention and behavior change on the job. What follows are the results of the two questions. The full sample available through December, 1994 is employed in the following analysis.
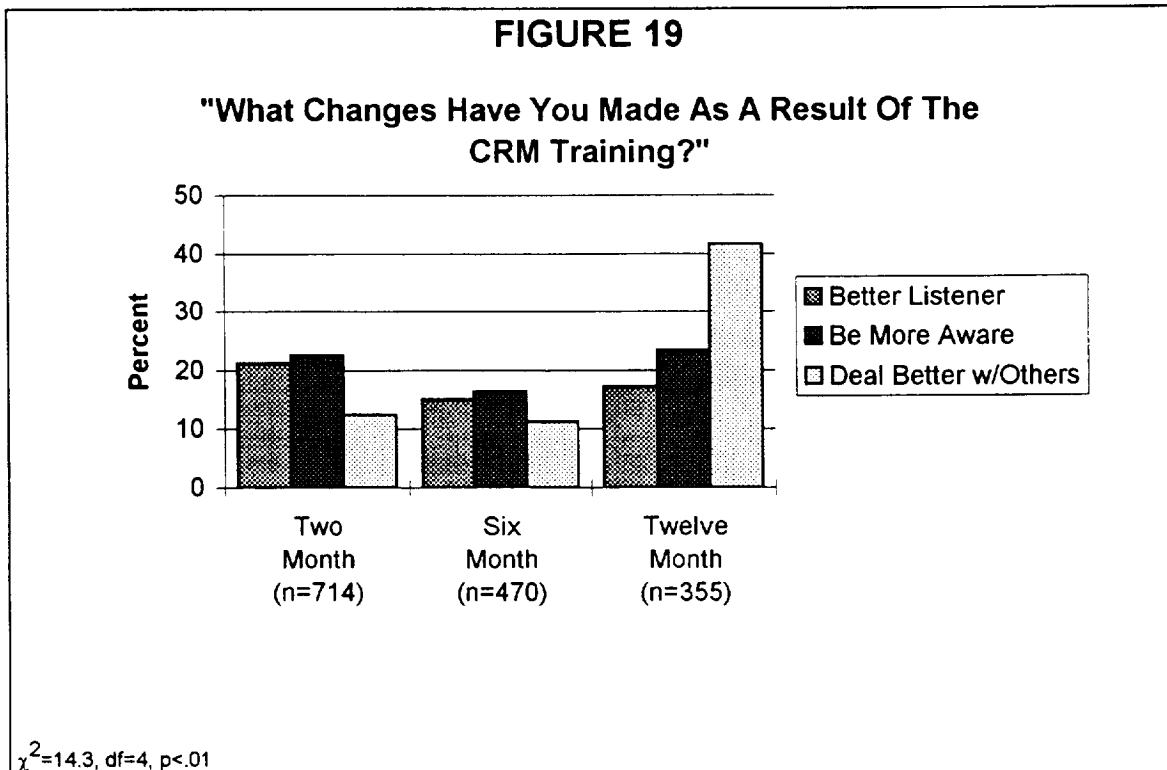
Open-ended question about intended use of CRM training

Participants were asked to write their responses to the first of these questions "How will you use this training on your job?" That question (*cf.*, Appendix B1, Q IV; Appendix B2 Q30) was included on the post-training, two, six and twelve month follow-up CRM/TOQ's. Content coding the participants responses to that question resulted in the bulk of the responses divided into three categories, including: 1) "Being a better listener," 2) "Being more aware of others" and, 3) "Dealing better with others. " These three categories represent two types of self-perceived potential behavior changes; passive and active. For the first two categories which we classified as "passive" behaviors, intended improvements are made within the person such as, "I am aware of other personalities and management styles" or "I am more tolerant of others opinions. " Conversely, the other category, classified as "active" behaviors, contains intended behaviors such as, "communicating better in giving instructions on work assignments," as well as "frequently using problem solving activities," "group consensual decision making," or actually, "dealing better with others. "

Figure 18 shows the results of the question for all four measurement waves. In the post-training survey, none of the three categories accounts for as much as 15% of those answering. In the subsequent waves of measurement in the months following, the two "passive" categories show a relatively flat infrequent pattern, while the "active" category "deal better with others" substantially increases to 37%. The significance of this pattern was tested using the Chi Square test, which revealed a clear difference. Clearly, there is a shifting pattern over the four survey periods taken after training from the passive reported behavioral intentions to the more active behaviors of working better with others and interpersonal interactions.

FIGURE 18

"How Will You Use This Training On Your Job?"

Legend:
- Better Listener
- Be More Aware
- Deal Better w/Others

χ^2=22.3, df=6, p<.001

Open ended question about how training was used on the job

Responses to the question "What changes have you made as a result of the CRM training" (*cf.* , Appendix B2 Q29) were content coded in the same three categories as the open ended question above. Figure 19 shows initially higher levels for the two passive categories ("better listener" and "be more aware of others") for the 2 month and 6 month surveys. By 12 months after their training respondents reported more active behaviors The patterns, in Figure 19, over time were statistically significant using the Chi Square test.

FIGURE 19

"What Changes Have You Made As A Result Of The CRM Training?"

Legend:
- ▨ Better Listener
- ■ Be More Aware
- ☐ Deal Better w/Others

Categories (with sample sizes):
- Two Month (n=714)
- Six Month (n=470)
- Twelve Month (n=355)

χ^2=14.3, df=4, p<.01

This pattern shift from passive reactions to the increasing use of active behaviors indicates that the managers are applying CRM skills and knowledge acquired from the training. Furthermore, the preferred behaviors have shifted from those behaviors people could do by themselves (e.g. , "be a better listener" and "being more aware of others"), to behaviors which involve others, such as "having more daily meetings to solve problems" and "gathering more opinions" and "getting more feedback from others. " It appears that after the training, the managers returned to the work site and began to process the training by first applying it to passive behaviors, such as being more aware of different personality and management styles, being more tolerant and patient of others' personal opinions. Then gradually over time, the participants became more comfortable with using these passive behaviors and recognized their positive effects, which then encouraged them to initiate more active behaviors. Thus, this increase use of active skills by the managers,

43

several months following the training, confirms that the learned CRM skills were achieved and improved interpersonal behaviors occurred.

Self-reported degree of behavior change

Shown in Figure 20 are the results of the managers' self-reported responses to the question about the effect of training on their behavior (*cf.*, Appendix B1, QIV; Appendix B2, Q28). A spike of "post-training" responses is seen for the category "large [behavior] change. " The subsequent "moderate" behavior change remains stable over the three remaining survey periods following the CRM training. These results suggest that positive behavior changes did occur following the CRM training and are likely to be a result of the training. Initially, it appears that the managers readily applied the knowledge gained from the CRM training to their work environment, then over time having had these behaviors already incorporated into their daily work routine, they reported a more moderate level of behavior change several months after the training. From the previous results of the managers comments, we know that these types of reported behavior changes occurring on the job are those of a more active nature.

FIGURE 20

Self-Reported Degree of Behavior Change: All Surveys

χ^2=25.1, df=9, p<.002
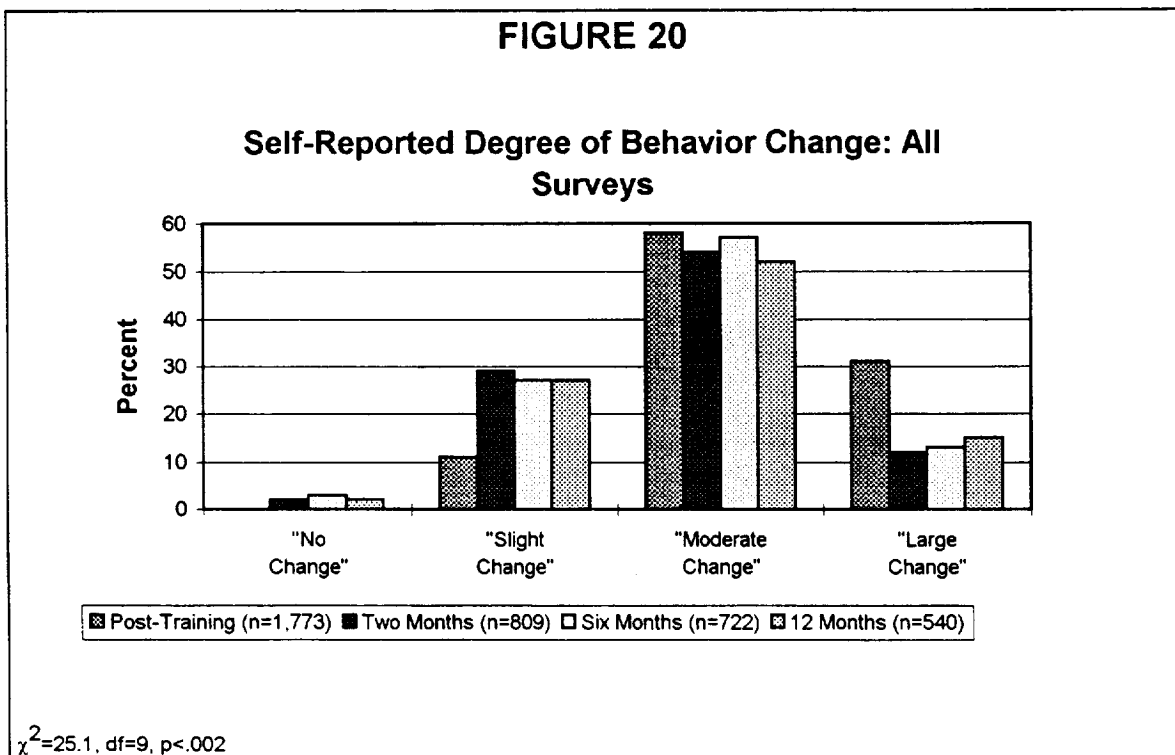
Analysis of Results of Field Interviews and Observations

Methodology for field interviews and observations

To validate the contents of the managers' self-reported behaviors as well as to expand the base of behavior measures used in the maintenance environment, we conducted field interviews and observations of the technical operations over a one year period (November 1993-November 1994). We selected maintenance sites based on their maintenance performance, geographical location, "organizational culture," and functions (e. g. , line stations and base maintenance hangars, and prime shops). Using the maintenance performance measures of dependability (departures within 5 minutes and late from planned maintenance) and safety (occupational safety and ground damage), we classified the stations into three categories of performance: low, medium and high and selected several from each category. We determined a representative sample consisting of ten U. S. city sites. We conducted individual and confidential interviews with a specified sample of maintenance managers who represented several levels of supervisory positions and work shifts: Regional and station managers (n=4), Supervisors (n=10), Assistant Supervisors (n=16), Technicians (n=6), and Administrative Assistants (n=2). We developed an interview protocol for these onsite interviews of maintenance managers consisting of questions pertaining to the successful transfer of CRM skills and knowledge to actual behaviors demonstrated at the jobsite. Four areas were covered in the field interviews: 1) determining what respondents liked and disliked about the training; 2) listing the applications of what they learned in their CRM training and how they had been using the training differently over time; 3) describing and elaborating their behaviors using examples from their work, and 4) describing upper management's support of the CRM training program. We observed the technical operations for all three work shifts as well as during the shift changes. It was during these shift changes, that we found a high level of discussions and interactions among the managers and technicians. These discussions focused on procedures involving the assignment of aircraft maintenance work and the clarification of work procedures.

Analysis of the interview data

We organized the interview data according to the four areas noted above. The following section specifically focuses on interview comments illustrating examples of passive and active behaviors. Subsequent sections review the interview data dealing with likes and dislikes of the CRM training, and the upper management support of the program.

Application of lessons learned and different use over time

The respondent's comments were classified as either examples of passive or active behaviors. These interview data were then compared with the written comments reviewed above. Tables 12 and Table 13 present the consolidated results of both the written comments and interview comments for passive and active behaviors, respectively. In these tables, we included only those interview comments that were stated by at least 50% of the

managers, as well as comments from the survey questionnaires that demonstrated the strongest examples of either passive or active behaviors.

The interview comments shown in Table 12 provide illustrative examples of passive behaviors that the managers were using after the CRM training program. These comments further support the finding that when the managers returned to the work site and began to process the training, they first applied it to passive behaviors. Many of the managers said that they were more tolerant of others, were better listeners concerning different inputs, and that they would try to "cool down" before they jumped to a conclusion. As the managers began to recognize the positive impacts of their attitudes, they became more comfortable using these behaviors and were encouraged to initiate more active behaviors.

TABLE 12
Comparison Of Written And Interview Comments
For Passive Behaviors

WRITTEN COMMENTS*	INTERVIEW COMMENTS**
Coded as "Passive Behaviors"	Coded as "Passive Behaviors"
"Think before giving my response"	"I stop and think when I get angry" n = 17
"Control my emotions"	"cool down" n = 15
"I am more tolerant of others opinions"	"More tolerant of others" n = 25
"I understand now that there are two sides of a story"	"I listen to the whole story now" n = 26
"I am aware of other personalities and management styles"	"aware of different management styles" and the variety of personalities" n = 24
"I understand how I react to stress"	"I manage my stress better" n = 31
"I am not judgmental as I used to be"	"I don't jump to conclusion and blame someone right off" n = 15
"I am a better listener"	"Better listener to different inputs" n = 22

* From Post-Training,, Two and Six months Follow-up Surveys
** n = 30, maintenance operations managers interviewed

Shown in Table 13 are illustrative examples of active behaviors that were used by the managers. Managers commented that understanding others' opinions and being more assertive in expressing their own opinions in meetings allowed everyone to fully understand why certain procedures and processes were done. For example, during the shift changes managers would insure that everyone clearly understood the current status of all aircraft, any urgent issues that needed to be addressed, and potential problems that might occur later in the work period. Openly recognizing the high stress conditions that would occur in their work situation, the managers expressed that they would communicate more effectively with the group by working with the team in understanding everyone's point of view. This would generally occur during their daily meetings that were scheduled between shifts. After thoroughly discussing potential solutions, the teams would come to a collective decision, fully supported by the team. Several managers said that slowing down the decision process and asking for feedback from their staff was beneficial. It was then understood why a certain decision had been made and everyone was part of the decision process. Even under stressful conditions, the managers stated that they would ask their workers if they understood their instructions and the procedures that they were suppose to follow by having them repeat back to them the instructions and why they were doing it in a particular manner. Doing this, they said, helped everyone understand what was to be done and the best way to get the job done.

An example of an active behavior engaged in by managers was communicating why certain maintenance job procedures and processes were called for. Those processes included selecting shift work schedules, overtime bidding, and safety procedures. The managers stated that once they asked for more feedback from their workers regarding work procedures, they began to receive constructive inputs from them on work issues that were important to them. Thus, the managers said that they would either communicate better why a particular work process or procedure was to be done or they would change the work procedure itself. Several times, the managers stated that they would visibly post the work process, such as shift bidding, in the break room for all employees to view. Then, if there were any specific questions as to why a certain process was taken, the managers could explain to the group, during their daily shift work meetings, as to how the process was decided and why. Many managers commented that when they did this, the problems that were occurring in the workplace seemed to be taken care of because everyone was informed. If there were any further questions workers could refer to the posted procedures posted in the breakroom. In some instances, the workers would have some ideas on how to improve the process since they had the opportunity to study the posted procedures. The managers said since their workers were better informed they were providing more constructive ideas and sometimes they would incorporate their ideas. Thus, a more constructive dialog among the work team would occur enhancing better communication among themselves

TABLE 13
Comparison of Written and Interview Comments
For Active Behaviors

WRITTEN COMMENTS*	INTERVIEW COMMENTS**
Coded as "Active Behaviors"	**Coded as "Active Behaviors"**
"We all have different opinions and viewpoints--more open minded and participative"	"understanding other's opinions by reiterating what they thought they heard" n=26
I am more assertive	"Being more assertive by voicing my opinions in meetings or discussions" n=22
"I ask the guys more questions now"	"Continuously working on saying what I mean to my co-workers as I as for feedback on what was understood" n=22
"Expressing the why of the process" "The why explained"	"Telling the workers the WHY behind the procedure or process-showing them explicitly why and taking the time for them to understand" n=27
"Encouraging others to recognize stress"	"Recognizing stress with aircraft problems and telling everyone we gotta work this one out together" n=28
"Communicating better under stress"	"A group decision we all came to--understood everyone's point of view--solutions arrived under the high stress level" n=28

* From Two, Six and Twelve Months Follow-up Surveys
** n = 30, maintenance operations managers interviewed

Likes and Dislikes of the CRM training program

What participants liked about the training. There was an overwhelming positive response from the managers about how much they enjoyed the class and the usefulness of the CRM training. Every managers interviewed commented that this training was one of the best courses that they had attended at this airline. Not only were they able to apply the training to their work environment, several managers said they also used the CRM skills at home, allowing them to "practice" their newly attained skills. Over 90% of the managers commented that the Strength Development Inventory (SDI) personality style exercise was one of the particularly good aspects of the CRM training. Using SDI, the participants were given information concerning their behavioral style with the implications of that style for human interactions and management practices. Learning ones' behavioral style under various workloads and conflict situations, appears to heighten the awareness and appreciation of how people will react and manage. The managers said that having

48

understood their behavioral style brought a sense of clarity about the responses of other toward them under various leadership and working situations. Also, understanding their boss' behavioral style helped them understand why the boss was managing the work units a particularly way.

Other training modules the managers particularly liked were assertiveness, stress management and active listening. Managers reported that that they better understood their own behavioral style and their bosses' behavioral style, learning how to become more assertive, manage stress better and communicate more effectively under stressful conditions was smoother and more productive.

Another aspect of the CRM training that the managers said they particularly liked was the mix of the participants in the class. Being in a class where the trainees were from other departments representing different functions and responsibilities, allowed people to gain an appreciation of the other mangers job functions, what their constraints and problems were, as well as how the outputs of their jobs affected others in the work system. There were several group exercises given in the training, allowing for small group of participants to work together which provided everyone the opportunity to actively experience, hear and discuss the how's and why's of arriving at a decision. Having this mix of participants drawn from the various line and base maintenance stations provided everyone with the opportunity to meet their co-workers and to associate an individual with a particular job functions. Several managers commented that this allowed them to see the "human" side of their work environment. For example, "Now I know who Charlie is at the line station and I feel much more comfortable with working with him on solving our problems." "It just seems to make the whole process a little easier and sometimes under our stressful conditions we laugh about which way our "arrows" are pointing." (In the SDI, each participant plots "arrows" according to their responses to several questions of how they would react to a situation under stress and under more normal circumstances.

Over 95% of the managers commented that they liked the role playing training exercise where the roles were defined and scripted and the scene was a believable interaction among mechanics, maintenance managers, inspectors and airline pilots. They all expressed that they would like to have more role playing exercises where everyone would be able to participate and experience the different roles.

Participants' dislikes of the training. No manager expressed that they did not like the training. The only item of concern, raised by two managers, was that sometimes the material presented was a little too theoretical, however this was not perceived as a big issue.

Upper Management's Support Of The CRM Training

It was expressed by every CRM training participant that they were pleased that the CRM training was a required activity with the complete support of the senior Vice President of Technical Operations. This type of support indicated to the maintenance managers that the company was very serious about this training and the intended skills and

knowledge that was to be acquired. Over 95% of the managers commented that with this type of training mandate, it allowed them to not have to struggle to attend the course, or justify their subordinates' time to attend this training program as well.

All of the assistant supervisors interviewed, reported that this was their only occasion to attend a training course which was not technical in nature but was related to developing their management and interpersonal skills.

All mangers commented that they would like to see management support for a refresher course to further develop and practice their newly acquired CRM skills. In the follow-up CRM training course, it was suggested that there should be more case studies, role playing exercises, group decision making exercises and conflict resolutions exercises. Furthermore, continuing the practice of having the CRM course participants representing the various job functions and roles was emphasized as very important by the managers. Several of them also said it would be valuable to offer the CRM course to the mechanics and inspectors as well. They would like to see management support the mandatory attendance of mechanics to a CRM course. This, they said, would provide a common base of working CRM knowledge and skill development among all technical operations personnel.

Several managers said it would be useful if relevant case studies or exercises could be provided to them periodically so they could pull together their maintenance team and constructively practice their CRM skills. It was suggested that using time in their monthly safety meetings might be an appropriate forum. if management would initiate and support this type of process, They said it would indicate to the technical operations personnel that the continual practice and application of CRM skills is considered important in the company.

Summary. Validation of the self-reported behaviors in the CRM/TOQ questionnaires was demonstrated by the results of the field interviews and observations. Confirmation of the reported change of behaviors from passive to more active and interactive behaviors over time, demonstrated the positive transfer of CRM learned skills and knowledge to the work environment and job. Commitment to using the CRM skills were shown, over time, by various communication interactions among the technical operations managers confirming and validating that CRM skills were incorporated into their daily tasks of technical operations. Illustrative examples collected during the interviews from several technical operations managers, provided testimonial evidence demonstrating and further supporting the success and positive effects that the CRM training had on managers' attitudes and behaviors.

CONCLUSIONS

The increased safety, dependability and improved costs associated with positive attitudes following the CRM training are strong effects, and they are attributable to that training. The impressive number and size of the correlations between post training attitudes and performance, together with the longitudinal association with performance months after the training are very convincing evidence for the positive effects of CRM training. The reported behaviors obtained from open-ended questionnaire items, on-site interviews and observations further confirm the real effects those numbers imply.

Comparisons of managers' attitudes immediately after their training with their pre-training attitudes show significant improvement. Improvement took place in attitudes about "willingness to share command responsibility," "usefulness of communication & coordination," and "recognition that stressors affect decision making. " The same attitudes of these managers two-, six-, and 12-months later reveal that these favorable post-training attitudes remain at those positive levels in the months after the training. The fourth attitude scale measured, "willingness to voice disagreement" (a measure of assertiveness), although showing no significant change immediately following training, improved significantly above the pre-training levels two months after training and it remained at that higher level six and 12 months afterwards. The influence of the training on all the expected participant attitudes is thus a stable and robust effect and not merely a brief "honeymoon" effect of good feelings immediately after the training.

Other analyses of the data looked at the relationships between the four attitudes and maintenance results over several years. In this "time-lagged" or longitudinal correlation analysis we tested the effects of the training program on performance. We compared performance before the onset of the training, to attitudes in subsequent time periods, as well as comparing attitudes with later performance results. We found an explainable pattern of significant relationships between the participant' pre-training and post-training attitudes, and between those attitudes and performance. Positive attitudes about "assertiveness," "sharing responsibility," and "stress management" -- all skills and behaviors specifically taught in the CRM training -- were more predictive of subsequent performance. Positive attitudes about the more passive belief, "communication and cooperation," seemed less sensitive to the CRM training and were less predictive of subsequent performance. The attitude, communication & coordination, was not found related to maintenance performance in any of the follow-up surveys. Positive attitudes were apparently initially valuable, as they suggested a sensitivity to more specific behaviors and later attitudes about assertiveness, stress management, and delegation.

Associations between positive post-training attitudes and subsequent performance were even stronger when attitudes were measured at 2 months and at 12 months after the training. Overall, the survey results from these 2 month and 12 month follow-up surveys are remarkably strong and indicate that lessons learned from the CRM training consolidate and strengthen in the months afterward, and in more "active" or practical ways. In most

cases the strongest relationships were found in the months following the measurement and they then trended downward for the remaining period.

The strong implication is that CRM training for maintenance managers and support professionals is effective if the behaviors taught are given time to develop. Once competence and early success is achieved consolidation takes hold and reinforces the positive attitudes making them more enduring. Simply letting time take its course does not assure the continued success of the program. The period between two months and one year following initial training should be an ideal time for recurrent training to sharpen the skills and to strengthen management resolve. Additionally the motivation and logic to extend the CRM training to mechanics is strong among past participants and this diffusion should be realized. With diffusion to mechanics, and recurrent training for all participants, we should then expect to find that ever increasing maintenance performance would be the outcome of the positive attitudes and inspiration resulting from "crew resource management."

Analyses of the managers' self-reported behaviors and interview comments confirm a shift of behaviors from passive, to more active and interactive behaviors over time. This demonstrates the positive transfer of CRM learned skills and knowledge to the work environment and job. Commitment to using the CRM skills were shown over time, by the various communication interactions among the technical operations managers, further supporting and validating that CRM skills were incorporated into their daily tasks of technical operations. As the managers became more comfortable with using passive behaviors and began to recognize the positive impacts that their attitudes had, they were encouraged to initiate additional active behaviors. We observed that at first, the managers reported and expressed that they became better listeners. Then over time, they began to become more assertive, handled stressful situations better, informing their workers about job procedures in scheduled daily shift work meetings, and understanding other's opinions better by repeating what they thought they had heard. With this increased use of active skills by the managers, the intended CRM skills were learned and achieved and improved interpersonal behaviors did occur.

There is a strong implication that greater reinforcement of this CRM for maintenance program would have enhanced the already very encouraging results reported here. That reinforcement could take several parallel and separable paths. First greater visible support from upper-middle management would confirm company commitment to the program. Such visibility would result from department executives and managers making a brief appearance at the opening or closing of each training session. Next, our results show that recurrant training in active and assertive communication skills would benefit participants, especially if that training took place within six months of the initial training (and perhaps as soon as two months afterwards). Finally, the advantage of including mechanics (Aviation Maintenance Technicians, or AMTs) in the training sessions was not lost on many participants, who suggested that this be done. In fact the company has recently begun a CRM program for AMTs and we look forward to learning of its successes.

REFERENCES

[Galaxy (1993)]. Taylor, J.C., B.A. Bettencourt and M.M. Robertson. The Effects of Crew Resource Management (CRM) Training in Maintenance: An Early Demonstration of Training Effects on Attitudes and Performance" (Socio-Technical Design Consultants, Inc., March 1992). Published as "Chapter 7"in Galaxy Scientific Corp. *Human Factors in Aviation Maintenance Phase 2 Progress Report* (Report # DOT/FAA/AM-93/5). Washington, D.C.: Federal Aviation Administration, Office of Aviation Medicine (April 1993).

[Galaxy (1994)]. Taylor, J.C., M.M. Robertson and D.L. Rosenbaum. Effects of Crew Resource Management (CRM) Training in Maintenance: Results Following One Year's Experience" (ISSM/USC, December 1992). Published as "Chapter 6"in Galaxy Scientific Corp. *Human Factors in Aviation Maintenance Phase III Volume 2 Progress Report* (Report # DOT/FAA/AM-94/12). Washington, D.C.: Federal Aviation Administration, Office of Aviation Medicine (July 1994).

Geirland, J.G. & J.J. Cotter (1990). *Social Analysis Questionnaire*, North Hollywood, CA: John J. Cotter & Associates, Inc.

Fotos, C.P. (1991). "Continental Applies CRM Concepts to Technical, Maintenance Corps," and "Training Stresses Teamwork, Self-Assessment Techniques." *Aviation Week & Space Technology*, pp. 32-35.

Gregorich, S.E.; Helmreich, R.L. & Wilhelm, J.A. (1990). The structure of cockpit management attitudes. *Journal of Applied Psychology*, 75, 682-690.

Helmreich, R.L. Evaluating the Effect of Cockpit Resource Management Training. (Abstract) Human Error Avoidance Technical Conference. Washington, D.C., 1989.

Helmreich, R.L.; Foushee, H.C.; Benson, R. & Russini, R. (1986). Cockpit management attitudes: exploring the attitude-performance linkage. *Aviation, Space and Environmental Medicine*, 57, 1198-1200.

Robertson, M.M.; Taylor, J.C., Stelly, J.W. Jr.; and Wagner, R.H. Jr. "Maintenance CRM Training: Assertiveness Attitudes and Maintenance Performance In A Matched Sample." In *Proceedings of the 21st Conference of the Western European Association of Aviation Psychology* (in press).

Sherman, P.J. (1992). "New Directions of CRM Training." *Proceedings of the Human Factors Society 36 Annual Meeting*, p.896.

Stelly, J. Jr. & Taylor, J. (1992) "Crew Coordination Concepts for Maintenance Teams." *Proceedings of the Seventh International Symposium on Human Factors in Aircraft Maintenance and Inspection -- "Science Technology and Management: A Program Review."* Federal Aviation Administration, Washington, D.C.

Taggart, W. (1990). "Introducing CRM into Maintenance Training." *Proceedings of the Third International Symposium on Human Factors in Aircraft Maintenance and Inspection.* Federal Aviation Administration, Washington, D.C.

Taylor, J.C., (1991a) "Reliability and Validity: Some measurement characteristics of the CRM/TOQ questionnaire." FAA, Office of Aviation Medicine, Biomedical and Behavioral Sciences Branch. Task 2 Report.

Taylor, J.C., (1991b) "Crew Resource Management (CRM) Training for Maintenance: Assessment of performance measures, and a demonstration of analysis plan." FAA, Office of Aviation Medicine, Biomedical and Behavioral Sciences Branch. Task 3 Report.

Taylor, J.C.; Robertson, M.M.; Peck,R & Stelly, J.W. Jr. (1993). "Validating the Impact of Maintenance CRM Training." In *Proceedings of the Seventh International Symposium on Aviation Psychology.* Columbus, Ohio, The Ohio State University,. pp. 538-542.

APPENDIX A

Technical Operations Division
Crew Coordination Concepts Syllabus

Module	Time	Facilitator	Method	Objective
Day 1 Introduction	8:15am (30 min)	TO	Introduce self. Cover facilities, restrooms, telephones, breaks, lunches, closing time. What have you heard about the course? Review PURPOSE, OBJECTIVES, WORKING AGREEMENTS. Collect Pre-seminar questionnaire. Explain purpose & importance of ID#. Group introduces themselves.	Position program as helpful in developing mgt. skills. Get group talking and energized. Set the tone of the workshop. Clarify expectations, yours/theirs. Remove teacher-student relationship.
Portland Video	8:45am (45 min)	HF	Show video; identify resource mgt. problems; relate Portland problems to work place. Prepare flipchart	Attention getter. Identify mgt. problems faced; problems become course focus/overview.
Expectations	9:30am (15 min)	HF	Develop expectations of individuals on course. Write on chart & compare to course objectives.	Get expectations from group, compare to course & illustrate differences if any.
Break	9:45am (15 min)			
Testing Assumptions/ DC-10 Video GUM	10:00am (120 min)	TO	Introduce concept of Perception vs Reality. Show DC-10 Video GUAM. Tablework: What were "Chain of Events" that led to the accident? Discuss "ASSUMPTIONS" that led or contributed to accident. How can we test our assumptions? What could each person have done differently?	Test Assumptions by: Advocacy - "Speaking Out" Inquiry - "Ask Questions" Active Listening - "Listening"
Lunch	12:00pm (60 min)			

57

Technical Operations Division
Crew Coordination Concepts Syllabus

Module	Time	Facilitator	Method	Objective
Day 1 continued Behaviors	1:00pm	HF	Discuss use of instruments; admin. SDI; develop Behav. Dim Model; discuss concept of "Assertive Behavior"	Understand behavior differences; understand strengths and weaknesses of behavior styles; assertiveness involves using a variety of styles (positively)
Break	2:15pm (15 min)			
Behaviors continued	2:30pm (60 min)	HF	Score SDI; Interpret SDI; draw arrows; discuss/applications; "Assertiveness"	People are different; behaviors influences communication. values, perception of others, decision making & conflict resolution methods. Behavior modification appropriate for effective supervision.
Break	3:30pm (15 min)			
Stress Management	3:45pm (60 min)	TO/HF	TO-Introduce/understand stress. What are sources of stress in our jobs? Develop list of Stressors. HF-Identify body's reaction to stress. Ways to deal with stress. TO-Work on how to deal with 2 examples. ETR'S, MANPOWER, ETC...	Stress is normal; stress can be managed; Recognize signs of excess stress. Effects of safety and efficiency Application of CCC to reduce stress.

58

Technical Operations Division
Crew Coordination Concepts Syllabus

Module	Time	Facilitator	Method	Objective
Day 2 Opening DC-10 Video GUM 041	8:15am (30 min)	TO	Show GUAM 041 video with breakfast. Address loose ends from Day 1; Outline schedule for Day 2. Review lessons learned in context of video	Transition and clarification; group at ease with where they've been and are heading; NOT A REVIEW!
Sub Arctic Survival	8:45am (60 min)	TO	Purpose of simulation. Make individual decisions (step 1). Make group decisions (step 2).	Tie into Day 1; position as a competition. This is fun!
Break	9:45am (15 min)			
SAS II	10:00am (60 min)	HF	Define/develop rational decision process; apply process to simulation; complete SAS; critique team effect; develop lessons learned, apply to job.	Problem solving involves a rational process; consensus decisions are better than individual decisions. Interpersonal skills impact decision making
Break	11:00am (15 min)			
Norms/EAL 855	11:15am (45min)	TO	Identify role of norms in Tech Ops. Introduce concept, give examples. Allow time to review EAL 855. Assign each table a role. What were norms that led to accident? Groups develop lists of good/bad CO Norms. Discuss how to manage norms and prevent accidents.	Norms play powerful roles in organizations. Have a direct impact on safety & efficiency. Assumptions must be tested. Norms are unwritten rules enforced by the group. Mgt. & FAA are powerless to change norms.
Lunch	12:00pm (60 min)		.	

59

Technical Operations Division
Crew Coordination Concepts Syllabus

Module	Time	Facilitator	Method	Objective
Day 2 continued Listening & Communication	1:00pm (60 min)	HF	Tie into SAS; Sleep exercise. Communication model; listening barriers; listening tips	Listening is a learned skill. Poor listening limits quality decision making.
Break	2:00pm (15 min)			
Supporting/ Confronting	2:15pm (60 min)	TO/HF	Use interactive dilemmas. Conduct 1st dilemma. Critique/lessons learned from 1st. Conduct second dilemma. How was second different from first?	Application of behavioral skills/style. Understand the variety of approaches; language is important. Use role play to demonstrate skills/lack of and need of practice.
Break	3:15pm (15 min)			
Wrap-up Evaluation/ Questionnaire	3:30pm (45 min)	TO/HF	Take Home concepts? USC/CAL Questionnaire explanation. I.D.#s on questionnaires.	Pledge to do something different/better. Feedback for program enhancement; participants feel good about experience.

APPENDIX B1

TECHNICAL OPERATIONS DIVISION
CCC WORKSHOP

POST SEMINAR

Please answer by writing beside each item the number that best reflects your personal attitude. Choose the number from the scale below.

*****Scale*****

1	2	3	4	5
Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly

____1. Technical Operations team members should avoid disagreeing with others.

____2. It is important to avoid negative comments about the procedures and techniques of other team members.

____3. Casual, social conversation on the job during periods of low workload can improve Technical Operations team coordination.

____4. Good communications and team coordination are as important as technical proficiency for aircraft safety and operational effectiveness.

____5. We should be aware of and sensitive to the personal problems of other Technical Operations team members.

____6. The manager, supervisor, or assistant supervisor in charge should take hands-on-control and make all decisions in emergency and non-standard situations.

____7. The manager, supervisor, or assistant supervisor in charge should verbalize plans for procedures or actions and should be sure that the information is understood and acknowledged by the other Technical Operations team members.

____8. Technical Operations team members should not question the decisions or actions of the manager, supervisor, or assistant supervisor except when they threaten the safety of the operation.

1	2	3	4	5
Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly

____9. Even when fatigued, I perform effectively during critical phases of work.

____10. Managers, supervisors, and assistant supervisors should encourage questions during normal operations and in special situations.

____11. There are no circumstances where the subordinate should assume control of a project.

____12. A debriefing and critique of procedures and decisions after each major task is an important part of developing and maintaining effective team coordination.

____13. Overall, successful Technical Operations management is primarily a function of the manager's, supervisor's, or assistant supervisor's technical proficiency.

____14. Training is one of the manager's most important responsibilities.

____15. Because individuals function less effectively under high stress, good team coordination is more important in emergency or abnormal situations.

____16. The start-of-shift team briefing is important for safety and for effective team management.

____17. Effective team coordination requires each person to take into account the personalities of other team members.

____18. The responsibilities of the manager, supervisor, or assistant supervisor include coordination between his or her work team and other support areas.

____19. A truly professional manager, supervisor, or assistant supervisor can leave personal problems behind.

____20. My decision-making ability is as good in abnormal situations as in routine daily operations.

1	2	3	4	5
Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly

In the following questions, "my management group" refers to those people who report to the same manager that I do.

___21. I am kept informed by others in my management group about the goals and objectives of this organization (e.g., cost, quality, service, etc.).

___22. Work goals and priorities are understood and agreed to by members of my management group.

In the following items, "my work group" refers to those people who report to me.

___23. Employees in my work group receive detailed feedback regarding the organization's performance.

___24. If employees in my work group disagree with the goals and priorities that have been established, they feel free to raise their concerns with supervision.

___25. Employees in other groups within Technical Operations plan and coordinate their activities effectively together with people in my work group.

___26. Employees in other groups, departments and divisions throughout the company act as if they share many of the same organizational goals that we do.

TRAINING EXPERIENCE AND EVALUATION

I.   For each of the topic areas or training techniques listed below, please rate the value of this aspect of the training to you. Rate each item by cooosing the number on the scale below which best describes your personal opinion and then write the number beside the item.

1	2	3	4	5
Waste of Time	Slightly Useful	Somewhat Useful	Very Useful	Extremely Useful

_____   Training in interpersonal communications and skills

_____   Assertiveness

_____   Conflict resolution

_____   Stress effects and stress management

_____   Analysis of personal styles and dimensions of team leadership

_____   Testing assumptions

_____   Training in skills using role play.

_____   Case studies of aircraft accidents and incidents

_____   Norms

_____   Active Listening

_____   Overall, how usefull did you find the training?

II. Technical Operations' _Crew Coordination Concepts_ training   has the potential to increase aviation safety and   t e a m w o r k effectiveness.   (circle one from list below)

Disagree Strongly	**Disagree Slightly**	**Neutral**	**Agree Slightly**	**Agree Strongly**

III. How useful will such training be for others? (circle one from list below)

Waste of Time	**Slightly Useful**	**Somewhat Useful**	**Very Useful**	**Extremely Useful**

IV. Is the training going to change your behavior on the job? (circle one from the list below)

No Change	**A Slight Change**	**A Moderate Change**	**A Large Change**

V.   How will you use this training on your job?

_____
_____
_____

VI.   What aspects of the training were particularly good?

_____
_____
_____

VII.   What do you think could be done to improve the training?

_____
_____
_____

Year of birth   _____

Total years at CAL   _____

Sex (M or F)   _____

CURRENT DEPARTMENT

_____   **Line Maintenance**

_____   **Base Maintenance**

_____   **Quality Control**

_____   **Planning**

_____   **Shop**

_____   **Material Services**

_____   **Engineering**

_____   **Other**

WORK LOCATION - CITY_____

: _____

Job Title: _____

Years in present position: _____

Past experience/training (# of years):

     Military   _____

     Trade School   _____

     College   _____

     Other Airline   _____

This completes the questionnaire
Thanks for your help.

APPENDIX B2

Date_____

TECHNICAL OPERATIONS DIVISION
CCC WORKSHOP SURVEY

"Six-month Follow-up" Questionnaire

Please enter the five digit Personal Identification Number that you selected at the beginning of the seminar.

Identification Code ____ ____ ____ ____ ____

Now, please answer by writing beside each item the number that best reflects your personal attitude. Choose the number from the scale below. All data are strictly confidential.

*****Scale*****

1	2	3	4	5
Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly

____1. Technical Operations team members should avoid disagreeing with others.

____2. It is important to avoid negative comments about the procedures and techniques of other team members.

____3. Casual, social conversation on the job during periods of low workload can improve Technical Operations team coordination.

____4. Good communications and team coordination are as important as technical proficiency for aircraft safety and operational effectiveness.

____5. We should be aware of and sensitive to the personal problems of other Technical Operations team members.

____6. The manager, supervisor, or assistant supervisor in charge should take hands-on-control and make all decisions in emergency and non-standard situations.

____7. The manager, supervisor, or assistant supervisor in charge should verbalize plans for procedures or actions and should be sure that the information is understood and acknowledged by the other Technical Operations team members.

71

```
                    *****Scale*****
        1              2           3        4          5
    Disagree       Disagree     Neutral   Agree      Agree
    Strongly       Slightly               Slightly   Strongly
```

_____8. Technical Operations team members should not question the
         decisions or actions of the manager, supervisor, or
         assistant supervisor except when they threaten the safety
         of the operation.

_____9. Even when fatigued, I perform effectively during critical
         phases of work.

_____10. Managers, supervisors, and assistant supervisors should
         encourage questions during normal operations and in
         special situations.

_____11. There are no circumstances where the subordinate should
         assume control of a project.

_____12. A debriefing and critique of procedures and decisions
         after each major task is an important part of developing
         and maintaining effective team coordination.

_____13. Overall, successful Technical Operations management is
         primarily a function of the manager's, supervisor's, or
         assistant supervisor's technical proficiency.

_____14. Training is one of the manager's most important
         responsibilities.

_____15. Because individuals function less effectively under high
         stress, good team coordination is more important in
         emergency or abnormal situations.

_____16. The start-of-shift team briefing is important for safety
         and for effective team management.

_____17. Effective team coordination requires each person to take
         into account the personalities of other team members.

_____18. The responsibilities of the manager, supervisor, or
         assistant supervisor include coordination between his or
         her work team and other support areas.

_____19. A truly professional manager, supervisor, or assistant
         supervisor can leave personal problems behind.

_____20. My decision-making ability is as good in abnormal
         situations as in routine daily operations.

1	2	3	4	5
Disagree Strongly	Disagree Slightly	Neutral	Agree Slightly	Agree Strongly

In the following questions, "my management group" refers to those people who report to the same manager that I do.

___21. I am kept informed by others in my management group about the goals and objectives of this organization (e.g., cost, quality, service, etc.).

___22. Work goals and priorities are understood and agreed to by members of my management group.

In the following items, "my work group" refers to those people who report to me.

___23. Employees in my work group receive detailed feedback regarding the organization's performance.

___24. If employees in my work group disagree with the goals and priorities that have been established, they feel free to raise their concerns with supervision.

___25. Employees in other groups within Technical Operations plan and coordinate their activities effectively together with people in my work group.

___26. Employees in other groups, departments and divisions throughout the company act as if they share many of the same organizational goals that we do.

27. How useful has the CCC training been for others? (circle one)

A Waste of Time	Slightly Useful	Somewhat Useful	Very Useful	Extremely Useful

28. How much has the CCC training changed your behavior on the job? (circle one)

No Change	A Slight Change	A Moderate Change	A Large Change

29. What changes have you made as a result of the CCC training?

_____

_____

_____

_____

30. How will you further use the CCC training in the coming months?

_____

_____

_____

_____

31. Looking back on it now, what aspects of the training were particularly good?

_____

_____

_____

_____

32. What do you think could be done to improve CCC training?

_____

_____

_____

_____

Year of birth   _____

Total years at CAL   _____

Sex (M or F)   _____

CURRENT DEPARTMENT

_____   Line Maintenance

_____   Base Maintenance

_____   Quality Control

_____   Planning

_____   Shop

_____   Material Services

_____   Engineering

_____   Other

WORK LOCATION - CITY_____

_____

:_____

Job Title: _____

Years in present position: _____

Past experience/training (# of years):

            Military   _____

            Trade School   _____

            College   _____

            Other Airline   _____

**This conpletes the Questionnaire
Thanks for your help.**

REPORT DOCUMENTATION PAGE		Form Approved OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE June 1995	3. REPORT TYPE AND DATES COVERED Contractor Report

4. TITLE AND SUBTITLE The Effects of Crew Resource Management (CRM) Training in Airline Maintenance: Results Following Three Years Experience	5. FUNDING NUMBERS NCC2-812
6. AUTHOR(S) J. C. Taylor and M. M. Robertson	

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Institute of Safety and Systems Management University of Southern California Los Angeles, CA 90089-0021	8. PERFORMING ORGANIZATION REPORT NUMBER A-950067

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) National Aeronautics and Space Administration Washington, DC 20546-0001	10. SPONSORING/MONITORING AGENCY REPORT NUMBER NASA CR-196696

11. SUPPLEMENTARY NOTES
Point of Contact: B. G. Kanki, Ames Research Center, MS 262-4, Moffett Field, CA 94035-1000 (415) 604-5785

12a. DISTRIBUTION/AVAILABILITY STATEMENT Unclassified-Unlimited Subject Category – 53	12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

An airline maintenance department undertook a CRM training program to change its safety and operating culture. In 2 1/2 years this airline trained 2200 management staff and salaried professionals. Participants completed attitude surveys immediately before and after the training, as well as two months, six months, and one year afterward. On-site interviews were conducted to test and confirm the survey results. Comparing managers' attitudes immediately after their training with their pretraining attitudes showed significant improvement for three attitudes. A fourth attitude, assertiveness, improved significantly above the pretraining levels two months after training. The expected effect of the training on all four attitude scales did not change significantly thereafter.

Participants' self-reported behaviors and interview comments confirmed their shift from passive to more active behaviors over time. Safety, efficiency, and dependability performance were measured before the onset of the training and for some 30 months afterward. Associations with subsequent performance were strongest with positive attitudes about sharing command (participation), assertiveness, and stress management when those attitudes were measured 2 and 12 months after the training. The two month follow-up survey results were especially strong and indicate that active behaviors learned from the CRM training consolidate and strengthen in the months immediately following training.

14. SUBJECT TERMS Active communication, Passive knowledge, Longitudinal performance, Training evaluation	15. NUMBER OF PAGES 74
	16. PRICE CODE A04

17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT